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Alan Dexter

BUILD FOR TOMORROW, PLAN FOR TODAY

NOT EVERY PC BUILD goes smoothly. Plenty of things can go wrong, even for experienced builders. We're at the stage now that we're not even surprised when we hit hiccups on the way to awesome PC nirvana. If you're prepared, and stay calm, you can usually sort things out before they descend into frantic chaos.

This issue we feature three (very different) builds, so it shouldn't come as a surprise that we had to navigate a few problems in their construction. I also ended up rebuilding my main test rig, but I'll come to why I had to do that shortly.

The big build this issue was for our cover feature; the gorgeous, pricey, water-cooled Mini-ITX build saw plenty of challenging times before we even opened any boxes. And once we did, we hit even more issues. You can read about our exploits in the main feature, starting on page 26, but rest assured we managed to overcome all the problems to produce a stunning slice of computing.

When it comes to building your own machine, timing probably isn't as vital as when producing a magazine, but it still pays to plan ahead and be organized. You can't allow for absolutely everything that could go wrong, but it's a good idea to try to control as much as possible, and have a plan in case something doesn't work. Be patient, don't try to rush through problems, and you'll be fine.

As for my unscheduled rebuild, this month we moved from our dingy basement to a new open-plan office. The good news was that we had a view, the bad news was that my PC tripped the power sockets three times once it was in its new home. We stopped at three because we figured something was wrong.

Of course, when you move a PC, there's plenty that can go wrong: A component can shift out of a slot, an errant screw can end up causing a short, coolers can pop off, cables get unplugged.... There's lots of different things that can stop a machine from booting. We checked all of these, but that wasn't quite what was happening here; the machine simply wasn't turning on.

Eventually, we managed to get to the bottom of the problem—it turned out that the over-the-top 1,500W PSU that was powering the machine was drawing more juice than the weedy extension cables installed in the swanky desks could handle. This beastly machine was tripping the circuit breakers even though it wasn't actually drawing that much power under normal load.

The solution? Rebuild the machine with a smaller power supply, of course. And swap the chassis for a slightly smaller one while I was at it, because the existing one was a little intimidating for my new-found office buddies. So, I ended up with a fresh-looking machine, even if the innards hadn't changed, and we didn't have to do anything as complex as resetting the circuit breakers (actually, we had to do that as well).

We couldn't have planned for this particular problem, of course, but we stayed calm, checked the components, and persevered to make sure we ended up with a working machine.

Alan Dexter is Maximum PC*'s executive editor and a punisher of hardware. He's been a tech journalist for over 20 years, and has no problem upsetting the PC industry as a whole.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Google Assistant to Talk for You

This year's I/O conference was all about AI

GOOGLE HAS such a hold on search engines that we use it as a synonym for the task. But Google is much more these days, and has much bigger plans. At this year's I/O conference, we got to see what's cooking, and most of it is based around AI, as the battle to be your digital assistant intensifies.

Google Assistant gets six new voices, including singer-songwriter John Legend. You won't have to preface supplementary commands with "Hey Google" anymore, and it will be able to cope with multiple requests in one command. A new mode called Pretty Please will respond favorably to "please" and "thank you." This can be configured for specific users, basically an attempt to make children more polite (good luck). Other goodies include greater home integration with other gadgets. So, it'll be able to turn your coffee machine on for you soon.

We were also treated to a demo of Google Duplex, which proved a big hit with the crowd, drawing gasps. Duplex enables Google Assistant to make a call for you, and carry out "real-world" tasks, such as booking a table at a restaurant.

Some suspicious types have questioned the voracity of the Duplex AI demo, noticing the lack of background noise, and the fact neither business answered the call by giving its name, or requested any contact details. Both demonstrations certainly went very smoothly. Live demonstrations are a minefield of embarrassing pitfalls, especially if they involve real people unexpectedly interacting with AI without any editing. Google would have been reckless to risk it without making sure it would work first.

Duplex tries to mimic human patterns of speech to the extent of including "ums" and "ahs" (disfluencies). This attempt to hide its artificial origins has caused a few raised eyebrows, and worse. "Transparency in the technology is important," claimed a Google spokesperson. If that's true, why the attempt to hide it? There have been calls for Google Duplex to announce itself at the start of conversations. As the dialogue is being recorded, there are legal implications, too.

Google CEO Sindar Pichai has said that Duplex raises important questions about "the impact of technology and the role it will play in our lives," and that "we feel a deep sense of responsibility to get this right." Good, because the last thing we want is a mass of AI-powered sales calls. People may like the idea of machines talking for them to complete mundane tasks, but whether people are going to relish having machines talking to them is another matter entirely.

AI has also found its way into Gmail—its Smart Compose will auto-complete your missive, suggesting whole sentences, rather than simply completing words for you. Great if you use a lot of repetitive jargon. It also finds its way into Google News for a "more rounded" delivery, and Photos, to suggest actions. It wasn't quite all AI—we also saw the developer version of Android P. Improvements include new system navigation for multi-tasking and one-handed use.

It's clear where Google's emphasis is—putting Google-powered AI at the center of your life. As Amazon and Apple are trying to do. The battleground for digital assistants is important, as it's a convenient gateway for other services.

Build such a system and, of course, somebody will try to break it. Two years ago, students demonstrated hiding erroneous voice commands in music. Now we have the "Dolphin Attack," put together by researchers at Zhejiang University in China. This uses ultrasound to control your assistant; it seems the mics are sensitive beyond human hearing. Thankfully, a 20kHz filter should fix this, but it is a worryingly simple hack, even if you do have to be within a few feet of the victim. Security for digital assistants is going to be increasingly important—today it can start your coffee machine, soon your digital assistant will be running much more. **–CL**

> "Duplex raises questions about the impact of technology and the role it will play
>
> *Google CEO, Sindar Pichai*

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YouTube Premium gets you all the goodies from YouTube Music, plus an ad-free library of videos featuring original content. These are being expanded with "bigger original series and movies." It'll have to be a very considerable expansion if it ever wants to seriously challenge Netflix or Amazon. YouTube Premium will set you back $11.99 a month—two bucks more than the outgoing YouTube Red, although if you already subscribe to YouTube Red, your bill won't change, which is a welcome sweetener.

The streaming music business is huge, and YouTube has captured a hearty slice—good for YouTube's advertising model, but not particularly popular with the music labels. Subscription streaming services do have some enviable numbers: over 70 million on Spotify, and similar numbers on Apple Music. These must be a tempting target. According to the International Federation of the Phonographic Industry, 85 percent of people using YouTube go there for free music. Once something has been established as free, it can be tricky to get people to pay for it. YouTube has been built around the advertising model, and for now, that will remain the case—until that stream starts running dry, at least. YouTube Red accounted for a tiny fraction of YouTube's revenue; this new configuration is unlikely to change that for now. **–CL**

FACEBOOK ATTEMPTS TO CLEAN HOUSE

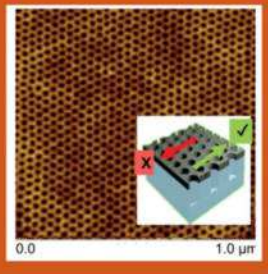
COMPANY KILLS 200 APPS AND 583 MILLION ACCOUNTS

FACEBOOK IS HAVING a PR nightmare, and there are signs it is taking some of the criticism to heart. Following the backlash against data harvesting by third-party apps, it has suspended 200 apps it suspects of passing on personal data, and is expected to suspend more as its investigations continue. "There is a lot more work to be done to find all the apps that may have misused people's Facebook data," said Ime Archibong, VP of Product Partnerships.

It has also deleted 583 million fake accounts in the first three months of the year. As it has 2.19 billion active monthly accounts, that's over 25 percent. In 2012, the company estimated fakes comprised about 7 percent of active accounts, two years later it was over 11 percent. Last year it deleted 694 million accounts. It's a massive game of Whac-a-Mole that Facebook isn't going to win without some restructuring to keep these invaders at bay. **–CL**

100X THE BATTERY LIFE, ANYONE?

Exotic cathode materials could unlock a better battery



RESEARCHERS at the University of Missouri, lead by Deepak Singh, have put together a battery design that could deliver orders of magnitude of power increases. The secret is a new cathode made from a nano-scale honeycomb lattice covered in magnetic alloy. This can conduct electricity in one direction only, and greatly reduces the heat and power dissipation current semi-conductor systems exhibit when switching. This latest effect exists largely as a computer model, but patents have been applied for, and a spin-off company is planned to turn the theory into something commercial.

We've been here before. Promising developments, often involving exotic materials as anodes and cathodes, have come and gone. The world is hungry for a better battery; power consumption is a constant bugbear for anything not connected to a power outlet. One of these projects will manage it someday soon, and nano materials have been the most promising avenue so far. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

STEAM SPREADS ITSELF
A new app means you can play your Steam library on an Android phone, an iOS version is to follow, with Steam Video clients.

COOL CANS
7-Eleven is to start selling cans of Fizzics cold brew coffee, complete with a CO_2 cooling system, which drops the temperature by 30 C.

NVIDIA MINING WIN
Cryptocurrency mining has helped put $289 million on to the GPU company's bottom line.

TRAGEDIES

NO 10NM THIS YEAR
Mass production of Intel's 10nm process has been pushed back a year due to technical problems with the laser lithography.

CELL CARRIERS SELL YOU
Due to a legal loophole, the big four firms have been selling your location to a private firm, leading to people being illegally tracked.

MACBOOK LEGAL ACTION
The failure rate of the MacBook Pro's butterfly keyboards has escalated into a class action.

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Jarred Walton

TECH TALK

RAM Speeds and Second-Generation Ryzen CPUs

WE TALKED ABOUT memory performance and timings a few months back, but it's a topic worth revisiting thanks to the launch of the second-generation Ryzen processors. For this discussion, I used the top-of-the-line Ryzen 7 2700X, with additional testing using a Ryzen 5 2400G APU.

First-gen Ryzen CPUs were more finicky with RAM sticks, especially at launch, and performance could also vary. I spoke with motherboard manufacturers, asking about memory performance and Ryzen CPUs in particular. One of the interesting tidbits is that Intel platforms apparently offer far more options for tweaking memory performance than AMD Ryzen platforms—about twice as many timings, with AMD microcode handling many elements of DDR4 training. That's apparently part of why memory compatibility on socket AM4 was initially so dodgy.

With further updates to the AGESA (AMD Generic Encapsulated Software Architecture) software, plus the refinement in the second-gen Ryzen parts, we get better performance and compatibility. One area where AMD cites specific improvements is cache and memory latencies—up to 16 percent lower L3 cache latency, 34 percent lower L2 latency, 13 percent better L1 cache latency, and 11 percent better memory latency. Combined, these improve per-clock performance by around 3 percent.

The reason for the modest overall improvement is that modern processors have a cache hierarchy designed to mitigate the pains of dealing with slow memory. Ryzen was an exception, with the Infinity Fabric running at the same speed as the DDR4 memory. I wondered if the improved cache and memory latencies would make DDR4 speed less of a factor, so I tested six 16GB kits ranging from DDR4-2133 CL15 to DDR4-3400 CL16, with several in between.

The results are as I expected. Applications that predominantly run from the CPU cache show very little change in performance, regardless of the RAM used. 3D rendering, data encryption/decryption, and even video encoding only saw 1-2 percent gains. Calculating pi digits with y-cruncher and data compression/decompression show larger gains of 5-10 percent. What about games?

I tested 20 games, and the gains can be quite large. *Dishonored 2, Far Cry 5, Kingdom Come: Deliverance,* and *Vermintide 2* frame rates improved by up to 15 percent. But if we eliminate the low-bar DDR4-2133 CL15 (which no one should buy at this point, as DDR4-2666 CL15 sells for roughly the same price), the benefit is halved.

Overall, fast memory with tight timings improved gaming performance by 7.5 percent on average, compared to the baseline DDR4-2133 CL15. Move to DDR4-2400 CL15, and the difference is only 3.8 percent. DDR4-3400 CL16 ended up a bit slower than DDR4-3200 CL14, as expected—that's a real-world latency of 8.75ns versus 9.41ns.

With the Ryzen 5 2400G APU, I tested gaming performance with the integrated Vega 11 graphics. The reduction in memory bandwidth has a far greater impact, with faster memory improving performance by 20 percent on average, and up to 33 percent in games such as *Shadow of War.* If you're thinking about building a budget gaming rig with a Ryzen APU, don't skimp on RAM.

It's a good thing that top-shelf memory is less of a requirement with the latest Ryzen CPUs, as RAM prices continue to be a sticking point. 16GB DDR4 kits could be had for $60 in 2016, with exotic kits at $100. The cheapest 16GB kits now cost $150—though it was $185 for a similar kit two months ago!

There are accusations of price fixing, with a class-action lawsuit in the works. We can only hope prices continue to drop, because the amount of DRAM going into smartphones, cars, PCs, graphics cards, and AI is only set to increase.

Games continue to show the largest performance difference between memory modules.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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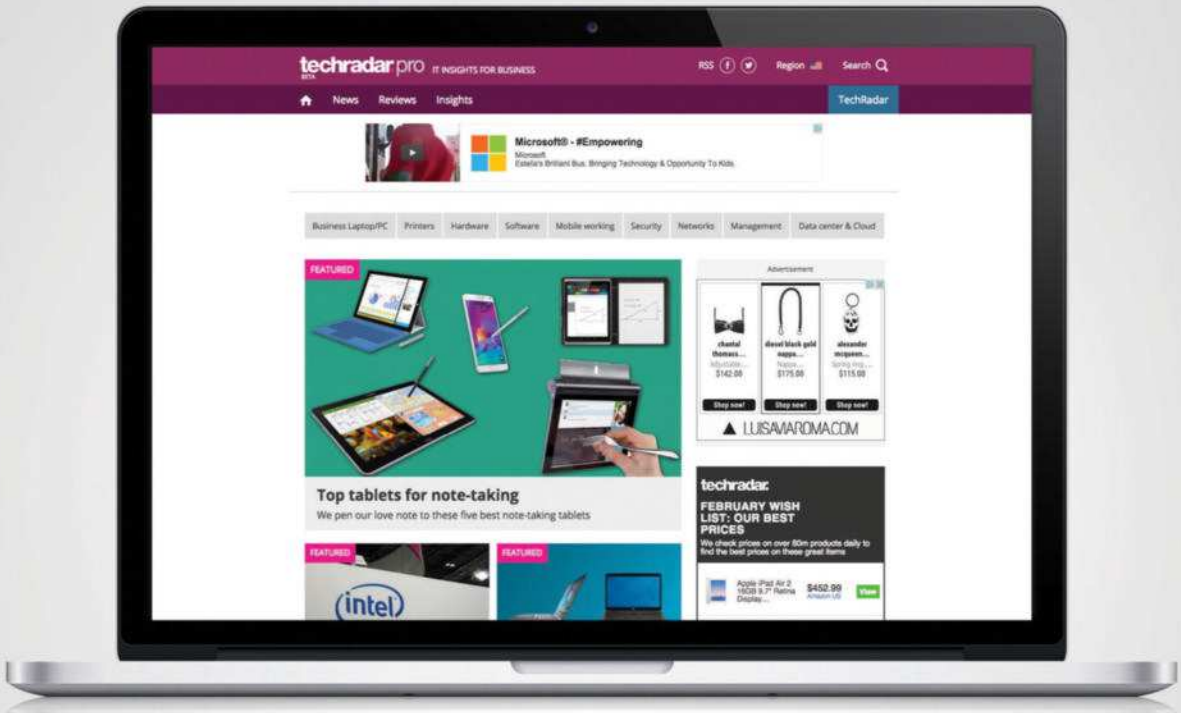
IT INSIGHTS FOR BUSINESS



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Alex Campbell

OPEN SOURCE

Get Your News the Old-Fashioned Way with RSS

WITH THE RECENT concerns about privacy on social media platforms and other "free" services, it doesn't hurt to look at your options. And if you use social media to get your news, there's a free alternative that's been around for a long time: RSS.

Really simple syndication is one of those seriously useful technologies that has somehow fallen out of favor in the past couple years. In the face of social media and the ever-broadening encroachment of big platforms on the web, it can be tough to find the stuff you want to read.

Last month, I explored the ways that someone could go about hosting (read: paying for) their own core services, such as email. I said there isn't a clear replacement for sites like Facebook, but given that so many people get their news from social media, there is an open and standards-friendly way to replace at least some of that functionality.

News and information bubbles have always been around in some form. Some people prefer the *Wall Street Journal* to the *New York Times*, for example. But algorithms created by big companies—most notably Facebook, Google, and Twitter—shape what articles we see. In essence, we're letting AI decide which articles are important to us.

For the publishing industry, this has long been a problem. There aren't a lot of readers who go straight to the front page of their local paper. Instead, stories are usually spread through social media. This led to the industry-wide adoption of cheap headlines and quick articles.

FeedReader on the GNOME desktop.

For the reader, this means the news you see in Google Now or on your news feed is a function of your interactions and search history. What you lose out on are the stories that aren't designed to be virulent. Niche stories can get lost, effectively thrown into the memory hole by algorithms. And as someone who sees how hard people work on stories, that really sucks.

Enter the trusty RSS feed. RSS has been around for ages. The technology enables you to subscribe to a feed, be it a podcast or news website. Some news websites go so far as to have an RSS feed for each section. Depending on the backend software running the site, you may even be able to follow your favorite writers' posts. All you need to take advantage of RSS is a feed reader of some kind.

RSS is a pretty simple technology. A feed is little more than XML containing the title and summary of an article. RSS feeds are capable of delivering the full-text content of an article at the publisher's discretion as well. (For the most part, blogs generally provide full text, while most news organizations would rather you view the story on their website.) As a result, RSS is a very open and easily interpreted format that nearly any software can be designed to read.

If there's one thing to know about feed readers, it's that there's no shortage of them. One of the leaders in the RSS space is the freemium service Feedly. Feedly is nice, but there's a ton of self-hosted and desktop RSS solutions as well. Tiny Tiny RSS is a lightweight, self-hosted alternative, for example. (You can even theme it to look like Feedly, if you prefer.)

Desktop apps are plentiful, too. Most mail applications, such as Evolution or Thunderbird, have some rudimentary RSS reader functionality. Dedicated reader apps are the better way to go, though. FeedReader is a GNOME application that can connect to different web-based readers or aggregators, such as Feedly or Tiny Tiny RSS.

The great thing about choosing an RSS application is that you rarely have to stick with that choice if you don't like it. Most RSS applications allow you to export your feed lists as OPML files.

Regardless of whichever app you choose, you bask in the knowledge that RSS can deliver content to you without the cruft of social media-induced advertising. You'll also be doing the outlets you like a service as well—you'll provide loyal readership.

Alex Campbell is a Linux geek who enjoys learning about computer security.

THE LIST

EIGHT ESSENTIAL GOOGLE CHROME EXTENSIONS

8 UBLOCK ORIGIN

If you're going to block ads, this is the extension to use—alternative Adblock Plus is in advertisers' pockets.

4 LASTPASS

Passwords seem to leak like a sieve made of Swiss cheese. Manage yours better with complete browser integration.

7 VIEW IMAGE

Google Image Search has, for some stupid reason, killed the "View Image" button. Get it back easily.

3 BRANCHER

Turn Chrome's list of recently visited sites into a properly organized and well-sorted history you can rely on.

6 REDDIT ENHANCEMENT SUITE

Add a ton of features to spice up your time-wasting Reddit browsing, including inline images and keyboard navigation.

2 STRICT WORKFLOW

Follow the Pomodoro technique—25 minutes working, five resting—by blocking social sites till it's time for a break.

5 DATA SAVER

If you're unlucky enough to be data-capped, Data Saver compresses pages before they get to you to save bandwidth.

1 ONETAB

Clean up that crowded tab bar and save a bunch of RAM by consolidating all your open tabs into one linked page.

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HEAD TO

BY **ALEX COX**

Netflix vs. Plex vs. Amazon Prime

We don't watch TV anymore. We consume media, and we do it on our own terms. We binge on series, gorge on visual snacks, and don't even bother to wipe away the crumbs. But just as there's no single best restaurant, there's no single best media provider: It's all a matter of taste. We've sidestepped Hulu, because your own kitchen (or, outside our stretched metaphor, your own media collection) could be the best way to serve up what you want.

ROUND 1

Library

Netflix and Amazon have been investing in their own content. Some of it is awesome—tastes differ, but we'd say Netflix's original series tend to best Amazon's examples—and it's generally exclusive to each platform. But the vast majority of each of their libraries is made up of licensed stuff that the companies doesn't own, and that means that the content you get from Amazon and Netflix is highly volatile. You could be halfway through a series, only to see it drop off the face of the earth when one of the companies' contracts comes due. The selection of movies available on each is, barring a couple of highlights, trending toward the bargain basement. And while you should probably keep your sense of entitlement in check when you're paying so little for so much, using both services can be frustrating.

Cooking up your own media library with Plex raises its own questions about ownership. DRM-protected digital files don't work, and ripping content you own from physical media means you're violating a license, even if the law doesn't make specific mention of its legality. But if you back it up, and mumble into your sleeve when asked where the content came from, that's a custom library that'll never run off and leave you.

Winner: Plex

ROUND 2

Interface

Barring occasional glitches, Netflix's library is organized in a clear, attractive manner, which makes discovering new stuff to watch particularly easy. It sniffs out the kind of content you like, often by using its secret clandestine categories; if you're opposed to a little data tracking, this probably isn't for you. Amazon's interface, at least on the web, borrows so many design cues from the store that it's verging on unpleasant to use, although it does a little better when it comes to its mobile apps. Step carefully while using it, or letting your kids use it, because not everything Amazon carries is offered as part of Prime Video—higher-end content is up for rental or purchase, adding extra fees on top.

Plex might surprise you with how well it manages a library of poorly named and format-flexible files. It's not absolutely perfect, but its library management features, which pull relevant information and imagery from a bunch of online sources, are generally accurate and automatic, and presented within an interface that you can configure exactly to your liking. You can syphon your files off into your own categories, and (if you're paying) split user accounts, so tiny eyes won't be ruined by horrific content.

Winner: Netflix

ROUND 3

Accessibility

Streaming services are streaming services, right? They are until they don't stream to the thing you want them to stream to. Amazon's stupid ongoing squabbles with Google mean that the only way to get Prime Video content piped in to your Chromecast is through screen sharing or streaming via a browser tab, which is inefficient and painful. Netflix is much happier to hit up just about any streaming device, from Roku to Chromecast to every smart TV worth its salt. There are probably toasters with Netflix support. Both have mobile apps that serve up the perfect level of content for your bandwidth, and browser apps that work well.

But what of Plex? Like sort-of-similar rival Kodi, it's supported on a whole host of devices, with a great mobile app to support it, and your library is available if you have the hardware. Plex does offer its own cloud service, but you're more likely to host your files yourself—and if you want them in an alternate format from the original, or at a slower bitrate, you need enough processing power to transcode those videos and convert them on the fly, and the upload speed to send them where you want them. With it, streaming anywhere is flawless and foolproof.

Winner: Netflix

HEAD

ROUND 4

Speed

Remember that comment about upload speed under "Accessibility"? Yeah. This is where Plex has the potential to fall apart. Even hosted on strong hardware, its interface speed is generally much slower than you'd find poking through Netflix and Amazon's libraries, and it can take a while for the monkeys to crank up enough transcoding steam to get your files up on screen. It's by no means a deal-breaker, but if you crave the dopamine hit of instant video, it's probably bottom of the pile.

Amazon's video, running through its massive server farm, gets to the screen almost impossibly fast, though it does take a while to get up to full resolution. Netflix, also usually running its files through AWS, is a few femtoseconds slower, but no slouch in the speed department, for now at least. Whether Netflix and Amazon Prime Instant Video stay snappy will potentially soon depend on which tier of broadband connection you're willing to stump up the cash for (thanks, FCC), and we have heard talk of certain nameless ISPs already throttling traffic from media providers; we'd imagine personal upload speeds will be similarly hacked away at, if less regulated countries are anything to go by. So, it's a bit of a moot point.

Winner: Prime

ROUND 5

Value

A base installation of Plex is free, and you get a fair amount of functionality for it. But filling your library with content isn't free, and we won't hear you arguing otherwise. Also, to get the full functionality out of Plex, you need to pay for its mobile apps ($4.99 on Android), and for a Plex Pass ($4.99 monthly) to do things such as adding parental controls. Netflix, tiered depending on how many devices you want to use it on simultaneously, has gone up in price over the past few years, currently $10.99 per month for the two-device package.

That's not bad, considering the amount of content on offer, but it's nowhere near as good as Amazon Prime's deal, which basically gives you a premium tier service from its whole ecosystem. Recently bumped to $119 yearly (there is a monthly plan, we swear, but it's hard to access and slightly more expensive, so you're better off sticking with the annual membership), it gets you expedited shipping, discounts on certain items, Prime Instant Video (obviously), as well as cool extras, like a free Twitch subscription every month, and, as a Twitch Prime subscriber, a pack of middling free games 12 times a year. We'd subscribe even if there weren't videos on offer.

Winner: Prime

And the Winner Is...

Taking a top-down viewpoint, Prime and Netflix each offer their own minor benefits (mostly revolving around exclusive content), and do just about everything else with the same flair as their rival. They have similar interfaces, offer a similar viewing experience, and work with the majority of devices—apart from Amazon's forced incompatibility with Chromecast. We lean toward Netflix's library at press time, but that could all change tomorrow.

From a nerdy standpoint, if not an objective one, Plex (as long as we avoid the awkward questions about sourcing content) is an absolute winner in the streaming stakes. It works beautifully without a vast amount of tinkering, it's easy to set up, and with a well-equipped streaming PC (and perhaps a few friends sharing their own Plex servers), there's little to no reason to invest in a monthly package with a limited, ever-changing library. So make your decision on those swampy moral grounds; if you've got the content, Plex is a sure winner, but if your own library is looking a little thin, give Netflix a try. Then can your sub when you're ready to watch those Amazon original series.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> RAID Reasoning
> DisplayPort Doubts
> Default Options

Laptop Upgrade

Hi Doc, I am using an MSI GT70 2PC notebook that is holding up fine for now. I'll likely keep it until they start offering 4K OLED screens on 17-inch desktop replacements. Originally, this system came with a 128GB mSATA SSD as the system drive and a 1TB 2.5-inch disk for storage, which I replaced with a 750GB Crucial MX300 to speed things up. The machine has two additional mSATA bays that aren't being used.

Despite my best efforts, the C: drive has filled up with Windows updates, software installs that don't let me specify another location, and Windows 10's inability to relocate the user folder. mSATA drives are becoming scarce and expensive. I'd like to buy a 512GB or 1TB 860 EVO, but I have a hard time sinking that much money into an aging machine. Both drives benchmark about the same. Can I just swap the bootable partition image to the 2.5-inch SSD, or does Windows have to run from one of the mSATA slots? I have a few external disks and a large NAS appliance to accommodate backing up and holding the images.

–Blake Bond

With its fourth-gen Core i7 and GeForce GTX 870M GPU, MSI's GT70 2PC gaming notebook has a bit of life in it still.

THE DOCTOR RESPONDS:

Technically, Windows should run just fine from a 2.5-inch SSD, so long as you jump into the notebook's BIOS and specify that drive as your first boot device. But because laptops vary from one model to the next, and troubleshooting is often configuration-specific, the Doc conferred with an expert from MSI's headquarters in Taiwan, who presented three possible scenarios.

The first is useful if you have a recovery disc created with MSI's BurnRecovery software. Back up all of your important data to one of your external drives. Then, remove the mSATA and SATA devices currently installed, replacing them with the 860 EVO. Use the recovery disc to get Windows loaded on your new SSD. Once it finishes, re-install the old drives into the notebook, taking care to adjust its boot sequence through the BIOS. Make sure the 860 EVO is first in line.

If you haven't yet created a recovery disc, find the product page for your GT70 2PC, navigate to the "Service" tab, click "Utility," select "Windows 8.1 64-bit" from the drop-down menu, and download MSI BurnRecovery. Underneath the download link, there are several hyperlinked questions about using the software. The first should walk you through using MSI's software.

Lastly, the MSI team considered that you might want to install a fresh copy of Windows 10 to replace the GT70 2PC's bundled version of Windows 8.1, which can no longer be upgraded for free. This would require purchasing a license for Windows 10 and temporarily removing the old drives as you load the OS on your Samsung SSD. The install routine will create a new MBR, after which you're able to reattach the old SSDs and use them as storage.

Backup Faux Pas

Hey, Doc. At the end of your section in the most recent issue of the magazine, it looked like your answer was chopped. You noted that you use RAID 5 with spare disks to assure your system is backed up. I'm sure you are aware this is not an adequate backup solution, though. It does not protect you against disasters caused by malware, theft, fire, fat-finger deletions, and so on. To protect against any of those, you need a true backup solution with off-

↘ submit your questions to: doctor@maximumpc.com

site storage. A cloud-based solution is excellent for this.

My current PC was put into service in 2012. At the time, I had 42 applications to install and configure. It was my second or third computer with mirrored drives in RAID 1, which I consider essential for preserving my years' worth of configuration. This protects the availability of data—a single disk failure has no material effect on my system's usability. Losing your boot drive requires the reinstallation of your OS and software. RAID (other than striping) does help prevent this, but it's not backup.

Now, here's my issue. I'm running Windows 7, and I'm afraid of destroying my system if I upgrade to Windows 10. I plan to build an entirely new PC for Windows 10 using double the RAM, mirrored M.2-based drives, and an MX500 SSD for data. I should be able to upgrade in less than six months. But would you recommend taking the leap now or waiting a year, hoping for Spectre/Meltdown fixes in hardware? **–Pete Matthews**

THE DOCTOR RESPONDS: The Doc took a lot of heat for that answer, Pete. And deservedly so. A dedicated storage repository collecting user data from PCs throughout the house is better than nothing, and it has helped avoid system-specific problems in his house for more than 15 years. Replace a PC? Reinstall an operating system? Stream terabytes of media to any workstation? No problem with a NAS appliance. But a fire could, in fact, wipe all of that out. So would a theft. The storage server is vulnerable to malware as well, as you point out. Although the Doc does run Acronis True Image on his personal workstation, even the incremental backups created by that software all live under one roof.

Addressing the limitations of local backup requires getting data off site, either through an online backup service, such as Carbonite or Backblaze, or a synchronized cloud-based drive, such as Google Drive or Microsoft OneDrive. Naturally, the best solution depends on your personal needs. Are you looking for a solution able to automatically upload the latest versions of important files in the background for safekeeping? Or is it more important to have ready online access to those files across all of your devices?

In the end, a more well-thought-out solution might involve many forms of backup: hardware redundancy to safeguard against disk failures, local software for capturing drive images, cloud-based backup for maintaining data across multiple locations, and a synching service to keep certain files easily available. For the record, readers horrified by the Doc's setup suggested IDrive online backup, Bvckup 2 for simple local backups, and Duplicati, an open-source utility that stores encrypted backups online.

As for delaying a new PC build, it's worth noting that Intel recently announced plans to ship updated eighth-gen Core CPUs with hardware-based fixes for Variants 2 (Spectre) and 3 (Meltdown) in the second half of 2018. AMD says it is not vulnerable to Variant 3 due to its processor design, but is actively deploying microcode updates for Variant 2 through motherboard partners. Variant 1 (also Spectre) is mitigated by operating system patches.

Connector Confusion

Hi Doc, I have some questions for you. I'm really confused about display connectors, specifically HDMI, DisplayPort, and USB type A/B/C. How about the versions of each (1.2, 1.4, 2.0, and so on)? And what about cable formats? If my TV has DP 1.4 and my graphics card is limited to DP 1.2, am I in trouble?

I want to buy a Wacom graphics tablet that needs a USB Type-C port supporting DisplayPort Alternate Mode, but what does that even mean? My PC doesn't have USB Type-C; can I buy a PCI card with this functionality built-in?

By the way, I love your magazine. Holding it in paper form is a wonderful sensation. Please don't give up on the printed version!

–Cesar Rosadio S.

THE DOCTOR RESPONDS: The system requirements for Wacom's Cintiq Pro specify that you need USB Type-C with DisplayPort Alternate Mode to run at 3840x2160, or mini-DisplayPort and USB Type-A for 2560x1440.

Breaking that down, USB Type-C and Type-A are physical connectors. Type-A is what you're most familiar with—it's prevalent on mice, keyboards, webcams, thumb drives, and so on. Type-C replaces Type-A (and B) with an easier-to-use reversible connector.

Although USB Type-C is backward-compatible with USB 1.1/2.0 transfer rates, the fact that Wacom specifies Alternate Mode support makes it clear we're talking about a host with at least USB 3.1 Gen 1. How does the Doc know this? Within that 24-pin Type-C connector, there are four high-speed paths normally used for USB 3.1 data. Support for DisplayPort Alternate Mode means one, two, or all four paths can be utilized for DisplayPort signaling instead. This is what gives the Wacom tablet enough bandwidth for 4K resolution at 60Hz.

If your motherboard doesn't have this functionality built-in, then yes, you need an add-in card to enable it. Support emails from Wacom suggest that some customers are successfully using the Sunix UPD2018, a single-lane PCIe 3.0 card with USB 3.1 Gen 2 support and a pair of USB Type-C ports. One of those two ports facilitates DisplayPort Alternate Mode capabilities. Sunix bundles a DP-to-DP cable that you connect between its input and your graphics card's output.

If your graphics card is, in fact, DisplayPort 1.2-compatible, you're fine. That standard offers up to 17.28Gb/s of bandwidth; 3840x2160 at 60Hz requires 12.54Gb/s.

Disappearing Defaults

Hi Doctor, I'm using Windows 10 Home (64-bit) version 10.0.15063 Build 15063. Every morning when I boot up my computer, Windows changes my default browser to Edge, and I have to manually change it back to Chrome. The same thing happens to the .pdf files on my desktop. The default gets changed to Microsoft Edge, and I have to change it back to Acrobat Adobe Reader in the shortcut properties.

It's a minor (but still annoying) hassle. So, I'm wondering if there's a way to tell Windows to stop changing my defaults and allow me to set those preferences permanently. **–Bob Klepner**

THE DOCTOR RESPONDS: This is one of those problems apparently shared by many, understood by few, and solved in a number of ways, depending on the root cause. However, on his site http://winhelponline.com, Microsoft MVP Ramesh Srinivasan suggests that the issue is user profile-specific, and mostly seen on systems with Local (rather than Microsoft) accounts.

As such, one proposed solution is simply switching to a Microsoft account. Open settings by pressing the Windows and I keys, then click "Accounts." Under "Your info," click "Sign in with a Microsoft account instead." You're prompted to either enter existing account credentials or create a new account.

If you'd rather stick with a local account, it's important to make sure Microsoft account information is scrubbed from the list of "Accounts used by other apps." Again, in the "Accounts" menu, select "Email & app accounts." Where you see "Accounts used by other apps," select your listed Microsoft app, and click "Remove." Hopefully, one of those solutions will prevent Windows from altering your defaults.

NEXT-LEVEL LIQUID COOLING WITH RYZEN

Follow our guide to building your own piece of computational perfection

EVERY TIME we hit up the drawing board for a build like this, there's a sense of apprehension. The degree of organization and luck required is Herculean, and even with all our experience, it never comes easy.

From planning the spec list, to requesting hardware, arranging photography, and more, it can take months for everything to come together, only for a new product to launch, or a shipping deadline to fall through, and scupper the entire thing.

Unlike our Dream Machines, these one-off specials are not about absolute power, and pushing everything to the bleeding edge of technology, but about crafting a PC that's perfect for the individual it's designed for.

Let's be realistic: You can probably get the same performance for half the cost, or twice the performance for less than double the price. But you rarely find someone who's invested this much time and effort into a rig and regrets it. It's a real labor of love.

This time around, we'll be crafting a super-small liquid-cooled ITX Ryzen 2 rig, packing some incredible hardware into as small a chassis as possible. On top of that, we'll be divulging all our tips and tricks to make the micro manageable, giving up our secrets on exactly which manufacturers and products we chose to make our system build as easy as can be, and hopefully inspiring you to create your own slice of silicon perfection, on any budget, in any chassis. –ZAK STOREY

PART		PRICE
CPU	AMD Ryzen 7 2700X	$325
GPU	PNY GeForce GTX 1080 Ti XLR8 OC	$970
Mobo	Asus ROG Strix X470-I Gaming	$210
RAM	32GB (2x 16GB) Kingston HyperX Predator DDR4 @ 3,000MT/s	$460
Storage 1	512GB Samsung 970 Pro PCIe M.2 SSD	$339
Storage 2	1TB Samsung 860 Evo SATA M.2 SSD	$300
Case	Lian Li PC-Q37	$220
PSU	Silverstone SX800-LTI SFX 800W	$190
Fans	4x Be Quiet! Silent Wings 3 120mm PWM High Speed	$88
Liquid Cooling	Assorted Alphacool Parts	$1,327
Cables	CableMod Configurator Pro + LED Strip	$159
Operating System	Windows 10 Home	$100
Total		**$4,688**

Eisblock XPX
LIAN LI

CPU

AMD Ryzen 7 2700X $325

Our processor of choice and the critical linchpin holding everything else in our rig together is AMD's Ryzen 7 2700X. It's no secret that we're fans of AMD's Ryzen architecture here at *Maximum PC*, both for reintroducing competition to the industry and for bringing more cores to the mainstream platform. That winning combination of strong single-core grunt along with multicore prowess on a mainstream platform is exceedingly appealing.

AMD's Ryzen refresh has been divisive—however, gaining a flat 10–15 percent performance increase, alongside improved memory latency, and some beefier overclocking headroom makes it a no-brainer for this build. Coffee Lake's Core i7-8700K was certainly tempting, but without delidding it, or running a monoblock to cover the chipsets (severely limiting our choice of motherboards), it wouldn't really be worth the extra single-core grunt that we'd achieve from it.

Choosing your processor is one of those decisions that really locks your build down. It's that platform-deciding choice that will dictate what memory you get, which motherboard you choose, and more, so making sure you're happy with that whole package is paramount when planning any system.

GPU

PNY GeForce GTX 1080 Ti XLR8 OC $970

GPUs are still in a very weird place right now. Ironically, on the flip side of AMD dominating the CPU portion of the market, the same just can't be said for graphics. Nvidia still rules the roost here, and with no foreseeable 11-series GPUs launching until after Computex this summer, the GTX 1080 Ti XLR8 was our card of choice, especially as it needed to drive at least one 4K screen.

It's by far the best value high-end card you can get, and it makes 4K gaming viable at high resolutions without too much trouble.

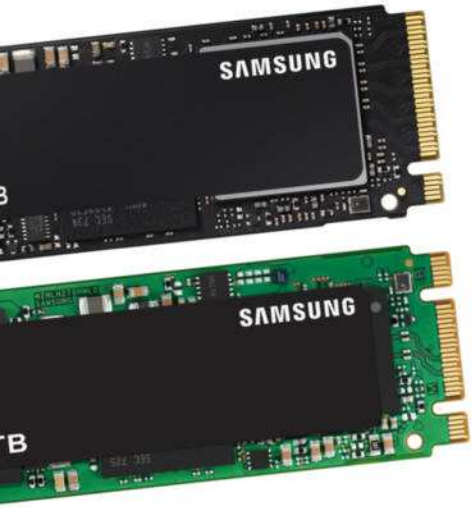
We went with the PNY XLR8 variant on this one, because it's one of the few manufacturers that still run the standard reference design PCB from Nvidia. The reason for this need was due to the fact we're using a prototype GPU block from Alphacool, designed to fit around the reference PCB of the Titan Xp or GTX 1080 Ti. That said, the difference in performance between this and something more sophisticated, such as an Asus ROG Strix or MSI Gaming X, is negligible at best.

MOTHERBOARD

Asus ROG Strix X470-I Gaming $210

When picking an ITX motherboard for a showcase system like this, it's imperative that you pay attention to the location of the 24-pin and CPU power ports. Especially for cable management, because many ITX cases aren't designed with vertical-mounted PCBs in mind, and some manufacturers place the 24-pin at the top of the board, or the EPS power midway down, which can be a little frustrating.

With Ryzen, there's a limited selection of ITX boards to choose from. Our decision fell on the Asus X370-I, thanks to its fantastic BIOS and neutral color palette. After speaking to Asus, it sent us an X370-I on the condition that we try to hold off as long as we could, and wait for the X470-I. Although there are no major changes, there's an improved rear I/O, and a more stylized design, which Asus was keen for us to show off. Luckily, the X470-I arrived in time, but too late for our photo shoot.



SSD

512GB Samsung 970 Pro PCIe NVME M.2 PCIe SSD $339

1TB Samsung 860 Evo SATA M.2 SSD $300

There's nothing like trying something new, and that's what we're doing here. We know Ryzen supports a single PCIe SSD M.2 drive over four dedicated PCIe lanes, but many motherboards have multiple M.2 ports, with some dropping the main x16 lanes for the GPUs down to x8, so you can populate the other port with a PCIe M.2. The question is: If that's an isolated event, down to the fact it's a PCIe M.2 SSD, what happens if you add a SATA M.2 drive?

To try to answer our question, we decided to run a single 970 Pro 512GB drive (if it arrived on time; if not, we'd use a 960 Pro 512GB), and add a 1TB 860 Evo M.2 variant. Samsung's Evo drives have long been a staple of many a budget build, and the company's 1TB range of drives is perfect for the avid gamer, looking for quick and responsive storage. That said, we've never checked out one of these beauties in M.2 before, so sticking this into the second M.2 port on the back of the Asus X470-I motherboard should make for some interesting testing, and a very snappy system.

MEMORY

32GB (2x 16GB) Kingston HyperX Predator DDR4 @ 3,000MT/S $460

Any Ryzen enthusiast knows that memory spec is imperative if you're going to get the most out of your AMD processor. It's an architecture that benefits massively from 3,200MT/s and higher, so this was one of our first concessions in the name of form over function. We could have gone with some Crucial Ballistix Elites, as we usually do, or Corsair Dominator Platinums with custom black light bars, but those are both kits we've used numerous times before, and we felt like a change.

You can get Predator DDR4 in 3,200MT/s SKUs, but those only come in 8GB DIMMs, and we wanted the absolute maximum capacity we could get, which means 16GB per stick. It might be possible, with a bit of extra voltage, to get the 3,200MT/s we desired, but for everyday running, 3,000MT/s should be just enough to keep up the frame rates, and make sure the Infinity Fabric is pumping out some juicy connectivity in all those multithreaded applications. As it turned out, things didn't quite go to plan, as you'll discover later in the feature....

LIQUID COOLING

Alphacool $1,327

Alphacool is one of the companies we've been itching to work with for a while now. We've been liquid cooling for a fair few years, but typically sticking with EKWB for the duration. Another European manufacturer, Alphacool is based just outside Wolfsburg, Germany. A place notorious for its precision engineering from the likes of Volkswagen and others. That engineering prestige absolutely comes at a cost, of course, but the quality of the componentry that Alphacool produces is second to none.

For our build, we had a few configurations in mind, but the plan was to take advantage of twin 240mm rads (one thick one, actively cooled in the roof, and a second skinny one in the bottom, running passively), then run a reservoir and pump separately. We'll be using soft tubing and fittings in the rear compartment, along with the D5 PWM pump, and frosted hard tubing in the front, with the reservoir and liquid-cooling blocks, too.

POWER SUPPLY

Silverstone SX800-LTI SFX $190

This is the real gem in this rig. An unbelievable feat of engineering on Silverstone's part, and damn impressive on multiple levels. And there's a few reasons as to why. First up is the form factor. By default, this is an SFX PSU—it measures an impressive 4.92 x 2.5 x 5.12 inches. It's unbelievably tiny in contrast with many of the giant 1,200W-plus monsters we've used in the past. It also comes packing an incredible 800W rating of max DC output, peaking at 850W at a push. It's the most powerful SFX power supply we've ever seen.

It's also fully modular by design, which means we have the opportunity to get in some custom cables from the likes of CableMod—or you could sleeve your own, of course. Then there's the 0dB fan technology on top of that, stopping the fan from kicking in until the PSU is at over 30 percent load. And then it has that 80 percent Titanium efficiency rating.

Each of these features on their own, on a standard power supply, would be nothing new, but combined into such a small package, they make the Silverstone SX800-LTI one of the most advanced power supplies on the market to date.

CABLEMOD PRO CABLES

We've also decided to splash out on some of that juicy CableMod goodness, this time going with the Pro configured cables. So, what do you get for these extra-pricey cables? Fully locked cable combs added on beforehand, mostly, in your choice of clear plastic or colored aluminum. We've also customized these cables to be shorter than standard. With each cable hand-sleeved and cut to size, specific to our build, it will minimize cable room in the rear, and hopefully make our building life easier.

CASE

Lian Li PC-Q37 $220

And here's our centerpiece: Lian Li's PC-Q37. It's subtly small and dual-compartmentalized, capable of housing twin 240mm rads, up to four 120mm fans, and dual 80mm fans. It's a beautiful combination of tempered glass and brushed aluminum, with a plethora of modern-day features.

It's not cheap, but Lian Li is known for its premium styling and high-end materials, and they don't disappoint.

That said, there are things to take into consideration. Due to the small form factor, you're limited to an SFX power supply, and there's only room for two hard drives in the rear compartment—2.5-inch or 3.5-inch—which is why we're trying to be a little smarter with our storage solution. You also need to be careful with your choice of GPU, making sure it's not too high. The PC-Q37 will happily support most reference cards, but a Strix, for example, or a thicker MSI GTX 1080 Ti will cause issues.

It's flawed but beautiful, and with the right liquid cooling, it's potentially a force to be reckoned with, too.

COOLANT

Mayhems X1 & Blitz Kit $60

For our coolant, we've decided once again to work with Mayhems on this project. The company provided us with the awesome Aurora particulated coolant for Dream Machine 2017, and the quality and dedication it gives its products is second to none.

Because this build is a flexible one, it's imperative we have options when it comes to color choice. From the get-go, we knew we wanted to keep the colors fairly basic, with only slight accents here and there. To this end, the custom cables are black, with a single red stripe, and the motherboard and blocks are black, too. That leaves us with three base colors—sort of—to work from as far as coolant is concerned: black, red, and clear.

Mayhem's X1 is a non-toxic environmentally friendly coolant, with plenty of biocides. We've got two liters of both the UV Oil Black coolant and the clear coolant (not to be confused with plain ol' water) for the build, which should be enough for all the blocks and rads, thanks to the build's small size. On top of that, we also requested in a Blitz Kit to flush out the radiators and blocks of any excess flux and radiator gumpf ahead of time, to ensure we have no coolant coloring issues or sludge deposits later down the line.

AIR COOLING

Be Quiet! 120mm Silent Wings 3/2 PWM fans $88

In essence, liquid-cooling is an advanced form of air cooling, but with more water vapor and surface area. What you use to cool that surface area, especially in a case with such limited internal airflow, is vital.

We've decided to opt for some of Be Quiet!'s Silent Wings 3 PWM high-speed fans. These 120mm beauties are super-quiet and pack some serious stats for their size. We're talking a max decibel level of 28.6, and air pressure coming in at 3.37mm H_2O, giving even Noctua a run for its money. We're not sure whether we can fit all four fans, and we've even got two 80mm Silent Wings 2 variants for the rear, in case we do something crazy, but when it comes to super-sleek fans, other than Noctua, Be Quiet! and Corsair are our go-to brands.

WATER WALKING WITH RYZEN

The trials and tribulations of building one of the world's most compact liquid-cooled rigs

LENGTH OF TIME:
24 HOURS TO BUILD
SIX MONTHS TO PLAN

LEVEL OF DIFFICULTY:
INSANITY-INDUCING

THE CONCEPT

WE MENTIONED back at the beginning of the feature how this special build differs from our Dream Machines: It's devised with a single person in mind, as opposed to just pushing everything to the max, like our big builds do.

This machine is designed around the whims of our crackpot deputy editor. ITX builds are a passion, and pushing as much power as possible into as small a form factor as possible is incredibly enticing. In fact, it's arguably what this industry has been all about for the last 60 years. Enabling more and more performance out of less and less space.

That said, this build project didn't actually start out with ITX in mind. There have been numerous revisions, countless spec list changes, and a whole heap of adjustments made before even getting to this point. Originally, we planned to take advantage of Intel's perfectly balanced Core i9-7900X—delidded, of course—housed in an Enthoo Evolv ATX. Then, with the advent of Spectre and Meltdown, we transferred our proposition over to the notion of Ryzen once more—a Ryzen+ build, to be exact—but still taking advantage of that ATX form factor, and with an SLI Asus GTX 1080 Ti configuration. Fast-forward to March/April, and that notion was finally shrunk down to an ITX system, and a second look at a custom-modded NZXT Manta, a chassis we'd worked on in the past. After we realized our custom case ideas couldn't be brought to fruition in time for getting the issue to print, we finally settled on working with Lian Li's PC-Q37—only for the spec to then get shaken up once again, with the launches of Samsung's 970 Pro drives and Asus's X470-I motherboard.

In the run-up to this issue, it's been hectic, to say the least. The organizational side of things has been turned on its head so many times, it's been enough to drive the chief color picker insane, and for the team at the *Maximum PC* photography studio to put out hits on all of us—deputy editor in particular. Stress, upon stress, upon stress. Why do we do this again?

LIQUID LUXURY

LET'S GET DOWN to the nitty-gritty as to what makes this build tick, and why we chose what we did. We're in a very unique position for once, because we'd usually write this segment after the build is complete. However, in this case, and due to the horrendously tight deadlines this build suffers from, we're actually writing it beforehand.

There are some huge variables in our build's spec, due to launch dates and shipping delays; the big ones being storage, motherboard, and memory. As backup, we have the Asus X370-I ROG Strix Gaming ITX mobo, 16GB of 3,200MT/s Corsair Dominator Platinum, and a 512GB/2TB single Samsung 960 Pro.

In an ideal world, and if everything pulls through for the final photography shoot, they'll be upgraded to an Asus X470-I ROG Strix Gaming, 32GB of Kingston Predator DDR4 @ 3,000MT/s, plus a Samsung 970 Pro 512GB combined with a Samsung 860 Evo 1TB M.2 drive. The latter are the perfect combination for this build. So far as hardware is concerned, it's that combination of storage solutions that particularly interests us, and that mostly stems around just how that second M.2 slot can switch between SATA and PCIe modes, and what overall throughput and performance will be with it.

Much like the cooling you add to a system like this, when approaching a water-cooled rig's construction, you need to be fluid in your approach. Get the hardware you want ahead of time, try to plan the layout as best you can, then work around each problem as you come across it. Sometimes, this means getting in more gear than you need, be it fittings, tubing, fans, you name it. It's a sacrifice that has to be made, especially in the smaller form factor builds, because clearances and bends become ever more complicated. We got in a whole ton of liquid-cooling fittings ahead of time: 12x 90-degree fittings, 8x 45-degree fittings, 4x snakehead S fittings, 12 standard hard tube compression fittings, soft tubing fittings, pass-throughs, Y bends, valve fittings, and excessive levels of extension fittings, in an attempt to make everything fit just right. We didn't end up using all of these, of course, because there's just no way to accurately predict how much you're going to need.

If you've got the time, it's always wise to do these builds slowly, buy the parts as you need them, get your tubing runs right, and don't rush it. It might take a month or two to complete, even with the applicable budget, but it's the only way to make sure you don't spend any more cash than you absolutely have to.

That said, if you ever do any more builds in the future, or even tweak your system, having spare fittings lying around can be a lifesaver, especially if you're in a pinch. For us, our build is yet to come—we'll see you on the other side.

1 PRELIMINARY FITTING

STEP ONE: THE DOOZY—the strip-down. It's so, so, so important you get this right, especially in a liquid-cooled build, particularly when it's as tight and cramped as this, because it's the perfect opportunity to see where your radiators fit, and try to figure out your tubing runs, and where you might need pass-throughs. In our case, we knew ahead of time we'd need every edge we could get. That meant reducing physical drives, cable clutter, anything that might cause an issue. The hard drive cage and grommet covers were all removed prior to the build shoot. Once we began, we got the motherboard set up ASAP—that meant CPU in, block on, memory in, and M.2 storage in. Once that was all secured, we quickly installed it to see exactly where we'd need to fit everything else.

2 RADIATOR CONUNDRUMS

WE KNEW THIS BUILD was going to struggle with airflow. Having no traditional front panel meant air access came from the bottom and top—and that was it. Problem is, there isn't enough space to mount fans in the bottom if you're using an additional radiator there as well. To get around this, we decided to invest in two slim 120mm Noctuas, and mount them on the underside of the chassis. We also had to move the radiator as far forward as we could to make sure the fittings wouldn't be blocked by the GPU. We used rubber washers with the screws, to secure the fans to the radiator, as they're 10mm slimmer than their standard counterparts, and we needed to make that up somehow. There's a few adjustments we can still make. In an ideal world, we would replace the feet with aftermarket custom-cut acrylic ones, to give the chassis more height, and allow us to use full-sized, more powerful Noctuas instead. Couple that with some fan guards, and we'd be good to go.

3 FAT FITTINGS

MORE RADIATOR CHALLENGES: this time from the top thick-as-hell 45mm rad. By default, the bigger 45s come with a massive reservoir at the end, alongside six individual G1/4-inch mounting holes (seven if you include the one at the other end), all of which need plugging. It's great for choices in loop orientation, less so when you're mounting them to flush radiator brackets, like the one on the PC Q37. As these stop fittings were pushing the rad down, we took the radiator mounting bracket out of the chassis, marked up where the fittings were going to go, found the center using a rule, drilled a pilot hole, then used a mandrel to take out the rest, allowing the fitting to pass through unhindered, and reducing our clearance issues. There's another removable brushed aluminum panel that sits on top of this, so our handiwork is hidden, but it'll also act as a drain valve or fill port when we have to do some loop maintenance.

4 RESERVOIR MOUNTING BRACKET

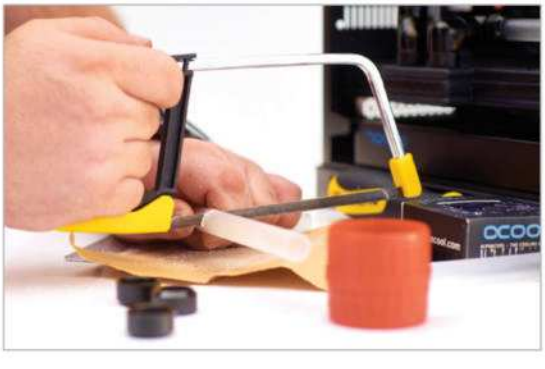
NEXT UP ON THE LIST of modifications to the chassis (and the first appearance of our bearded modding assistant) is a reservoir mounting bracket. We didn't really need to add this bracket, as the reservoir is secured by two 15mm-long extension fittings coming off the bottom radiator, and a second fitting coming out of the bottom-right of the res, connecting to a future drilled pass-through, going through the motherboard panel and into the pump, hidden on the other side. That said, to keep our res sitting proud and level, adding this bracket (included with the res) makes sense. Using a permanent marker, and some extra hands to hold the res in place, we marked the holes we needed to drill, before pumping through that soft gooey aluminum with a standard 4mm drill bit. You might notice the use of a sticky note here; fold it to create a tray, and attach it below where you intend to drill, to catch all the metal filings.

5 PUMP SHENANIGANS

THIS PART WAS POSSIBLY the most frustrating. From past experience, we knew soft tubing in the rear of the case was going to make our lives easier. Unfortunately, due to the lack of room and the need for pass-throughs in places for the reservoir, the tight curves led to the most obvious tubing runs kinking, which is bad. In the end, just to fit the pump in the chassis, we had to remove one of the plastic grommets that hold the side panel in place (there are seven in total, so losing one isn't the end of the world), then run four 90-degree fittings, with the smallest slither of soft tubing between to reach the pump inlet. To finish the loop, we ran an additional length of soft tubing straight up from the left-hand side of the pump to a second pass-through in the roof, connecting to the radiator on the other side.

6 CUTTING BLIND

WE KNOW WHAT YOU'RE THINKING: No guide, no securing tool, cutting straight down on a table, with a hacksaw? What? Don't worry. You can be super-anal about cutting tubing, but you don't need to be. It doesn't even need to be that straight a cut. The best way to cut tubing is to work out how long a length you need, and cut it with a hacksaw, in as comfortable a position as possible. Make sure you stay safe, of course, and cut off more than you think you'll need, but if you mess up the end, don't sweat it. If the cut is wonky, use sandpaper or needle files to smooth the rough edges and make it level. Next, use a deburring tool to give your tube some soft edges, making it easier to fit, then sand it some more to get rid of the grit, blow it out, and bam! Job done: one straight, level, chamfered, clean tube.



7 90 DEGREES 4 LYF

THERE'S A PHRASE we always repeat to ourselves whenever it comes to building liquid-cooled rigs: "Keep it simple, stupid." This is especially relevant with tubing runs, where it's almost always a better decision to use a fitting in place of a bend, unless there's no other option. If you do want bends in your tubing, the best way to integrate them is through pure 90-degree angles. They're the simplest and quickest bend to create—you don't need any carefully crafted angle templates or anything weird, because the whole world is literally filled with 90-degree angles. Us humans, we love square edges. In this case, to make our bends, we're using the edge of the chassis itself to line up our 90-degree angle, mid-bend, to make sure it's the perfect shape. This particular tube will go on to become our CPU-to-GPU line.

8 FITTINGS WITH STYLE

THIS IS WHAT we were talking about. You can see we've used a rotary S-fitting (acting as two 90-degree fittings) to connect a 90-degree length of tubing from the GPU to the CPU block. This way, we can keep the tubing looking clean, straight into the GPU block, without harming the overall aesthetics. The other 90-degree line coming out of the GPU is a combination of two 90-degree fittings, followed by a length of tubing with a 90-degree bend, which goes down into the radiator below. This allows the coolant to pass into the rad, then up through a male-to-male rotary connector and two extensions, which then go into the reservoir. The smart thing about having those rotary extension fittings below the reservoir is that we can rotate the res, without losing compression on the rubber o-rings, which lets us test other tubing runs without unscrewing the res entirely.

9 THE LITTLE DETAILS

THE SMALLEST PARTS in a liquid-cooled build are the most difficult to work with. This little length of tubing, connecting the pump to the pass-through and into the radiator, took us 45 minutes to get right, perpetually sanding and shortening it to get it to fit correctly. Even then, we realized the pass-through itself needed to be moved ever so slightly to the left, purely to keep the tubing run straight and level. That's not an absolute necessity, more of an aesthetic design decision, if anything. But because aluminum is so soft to work with, as metals go, it's easy enough to take a needle file to it, and just shift the pass-through ever so slightly to perfect the tubing run. On top of that, the smaller you go, the more troublesome it becomes to secure the compression fitting tops, because you start running out of space.

10 PRIMING UP

DECISIONS, DECISIONS. Once all our tubing runs were complete, there was one last decision to make: coolant color. We decided to go with the Mayhems Clear X1 as opposed to the UV Black we also had, because the frosted tubing Alphacool sent us looked so sexy on its own. Running black coolant through it would take away some of the aesthetic love. That, however, was the least of our worries, because we had to fill and prime the loop first, which is a daunting task with even a simple loop, never mind ours. For this rig, we had to tip the entire system sideways, unscrew the cap on the side of the reservoir facing upward, then partially fill the res as high as we could, screw the cap back on, turn it back up, power cycle the pump until the res was empty, then repeat until done.

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1 **The CPU block is a combination of the standard acetal variant plus a modding kit, which provides us with the red thumbscrew tops and the red Alphacool LED logo in the middle.**

2 **For aesthetic reasons, this build is running in a negative pressure configuration, which means more cleaning for the lucky end user.**

3 **A bit of sandpaper and a needle file could reduce the height of the angle on this length of tubing by just enough to straighten it up a touch.**

4 **Replacing the tubing length should allow us to get better access to that reservoir top, meaning easier filling, and a nicer-looking rig.**

WATERWORKS

THAT'S IT, THEN. We're done, wrapped up, finished. Or are we? No. There's plenty more to do. We ended up taking three days to build this rig. Even with the help of Alphacool's marketing rep and pro-modder, Dave Alcock, it took nearly twice as long as we expected. And there are still erroneous parts and little niggles to tweak to make this rig really shine.

First on the block are those Alphacool radiators. There are two annoyances here: the bottom rad's logo is upside down, and the logos are blue. To get around this, we're going to get some red vinyl Alphacool labels printed up, which we can overlay on them.

Next on the list is the memory. In the end, HyperX couldn't get the kit we wanted to us in time. No one's at fault, as it was down to an erroneous shipping delay handled by a third-party courier. Because of that, we had no choice but to lean on 16GB (2x 8GB) of Corsair's Dominator Platinum DDR4 @ 3,200MT/s for this build—the backup RAM we mentioned earlier—fitted with a couple of lightbar upgrades. But again, silver and white doesn't match our build, and that spec isn't the 32GB we'd hoped for, so a quick pitch to Corsair may be in the pipeline. To cure the silver and white bars on top, CableMod sells a black variant of the lightbar upgrade kit, with a red LED strip in the middle, too, so that should help smarten up the interior a little.

There's a lot we can do with the cable management in the back, too, as we were up against the wire here, so that's going to be addressed almost immediately. We've also got to find a plan for our simple six-way XSPC fan controller. And the magnetic LED strip we've hidden in the front corner of the chassis needs a stronger form of adhesive, Velcro perhaps, as the aluminum support bar isn't magnetic.

Lastly, there are some loop tweaks we could do. There's not a lot we'd change here; perhaps sand down the radiator end of the GPU tube, to bring the angle down a touch, and work on a fancier length of frosted tubing to connect the CPU and the top rad together, perhaps consisting of two 90-degree bends, and reducing our reliance on fittings.

All that aside, and the frustration, delays, and massive effort involved from everyone on the team, we're immensely proud of this build. It's cool, quiet, and lovely to look at, even with its flaws. It performs like a trouper, and kicks Maximum ass. There'll be more of this beauty (hopefully with all the tweaks) in a later issue, including the final desk build and peripheral setup, so keep an eye out!

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	2,178	1,832 (-16%)
CrystalDisk QD32 Sequential Read (MB/s)	3,136	3,554 (13%)
CrystalDisk QD32 Sequential Write (MB/s)	2,126	2,312 (9%)
Rise of the Tomb Raider (Avg fps)	68	72 (6%)
Total War: Warhammer II (Avg fps)	42	43 (2%)
Tom Clancy's Ghost Recon Wildlands (Avg fps)	38	38 (0%)
3DMark: Fire Strike (Index)	6,988	7,049 (1%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an Intel Core i9-7900X, 32GB G.Skill Ripjaws V Series DDR4 @ 3,000MT/s, an MSI GeForce GTX 1080 Ti Gaming X, and a 512GB Samsung 960 Pro PCIe SSD. All tests performed at 4K at the highest graphical profile.

BARGAIN HUNTING

Turn an old office PC into an incredibly affordable gaming platform—but make sure you do it right

If you're looking for a second PC, a compact gaming box, or an upgrade from an ancient rig that coughs out dust and grinding requests to be put out of its misery every time the fans start spinning, you might be tempted to take out a new credit card and a lien against your home to afford the latest gear. But accepting a small amount of compromise means you can build a new rig that will muscle through the majority of top titles and won't cost the earth—in fact, it could cost less than a console and do a better job.

But what compromise? The first is accepting that you don't need a monster GPU. The currency mining crew has swallowed up all the good ones. Rarity and the inconvenient realities of market forces mean the prices are sky high, and until the bubble bursts, there's a solid financial argument that staying away from the highest end is best for the average PC gamer. You also don't need a super-modern CPU, particularly if you're leaning toward gaming. Previous generations still have a lot of muscle left, and they're common enough that they're ripe for exploitation.

The other big compromise might sting: You're going to have to drop your aesthetic aspirations. Tinted windows, pretty RGB accents, and gorgeous water-cooling layouts are all well and good, and we won't argue that they don't play a big part in the allure of the modern PC, but they cost money we simply don't have to spend. Our plan means settling for a machine that's more functional than fancy, something that gets the job done with no fuss and no expense other than that which is strictly necessary, and that often means a no-frills black box. Put those cares aside, pick up the right components, and you'll have a highly serviceable and fundamentally decent machine. You won't get any sort of forward upgrade path, but for the money, who's complaining? –ALEX COX

A problem has been detected and Windows has been shut down to prevent
damage to your computer.
DRIVER_IRQL_NOT_LESS_OR_EQUAL
If this is the first time you've seen this stop error screen,
restart your computer. If this screen appears again, follow
these steps:
Check to make sure any new hardware or software is properly installed.
If this is a new installation, ask your hardware or software manufacturer
for any Windows updates you might need.
If problems continue, disable or remove any newly installed hardware
or software. Disable BIOS memory options such as caching or shadowing.
If you need to use Safe Mode to remove or disable components, restart
your computer, press F8 to select Advanced Startup Options, and then
select Safe Mode.
Technical information:
*** STOP: 0x0000000C (0x0000000C,0x00000002,0x00000000,0xF86B5A89)
*** gv3.sys - Address F86B5A89 base at F86B5000, DateStamp 3dd991eb
Beginning dump of physical memory
Physical memory dump complete.
Contact your system administrator or technical support group for further
assistance.
CIBOX
DVD
RW
DVD
ROM
disc
intel
Core 2
Duo

Office machines can be easy to work on, as they're built for quick servicing.

IMAGE: PASCAL VOLK

Be careful when searching by brand: All four of these machines are labeled "Optiplex 9010," but they're very different.

Gigabyte's GT 1030 is single-slot, low-profile, and cheap: perfect for an ultra-budget gaming box.

Tattered it may be, but a COA sticker is your path to a legit copy of Windows.

IMAGE: WIKIMEDIA COMMONS

Pick up a PC

Used hardware can be a minefield. Head to Craigslist, and search for "gaming PCs." You'll see a bunch of plasticky monstrosities that are definitely showing their age, you'll find some unrealistically priced machines that are clearly either not as described or hotter than a three-dollar bill set on fire, and you'll find incredibly well-heeled and burned-out boxes from people desperate to recoup some of the investment they've made on a new PC. They've upgraded because that old PC isn't just a few steps behind—it's at the end of its life.

We recommend looking in a different direction: at office PCs that have outlived their leases. Yes, they'll have been well used, but they're unlikely to have been thrashed. And office PCs, previously operated under service contracts, are made of enterprise-class components guaranteed to work well together and for a long time. There are thousands of these machines kicking around, cast off in floor-wide upgrades, and the good news is that the current crop packs some pretty mean hardware.

There's a bunch of brands to look out for—see "Best Budget Brands" opposite—but the key spec to watch out for is the CPU. Ignore first-gen Core i3 or i5 chips as, while they're OK, the price difference in machines toting second or even third-gen chips is negligible at best, and later processors and chipsets include technical upgrades beyond just speed. Even a Haswell CPU might be on the cards (our particular example machine, packing a Core i5-4590, was a steal), but they're less common in this class, and you should expect to pay a little more.

Don't, whatever you do, opt for an old office box with a Core 2 CPU or a Pentium. They're utterly inadequate, even if you're just looking to put together a new media center. They're not worth the silicon they're etched out of, particularly given that there's no way you'll be digging up a Kaby Lake Pentium, which actually moves pretty fast, when you're looking in this bracket.

Where to look

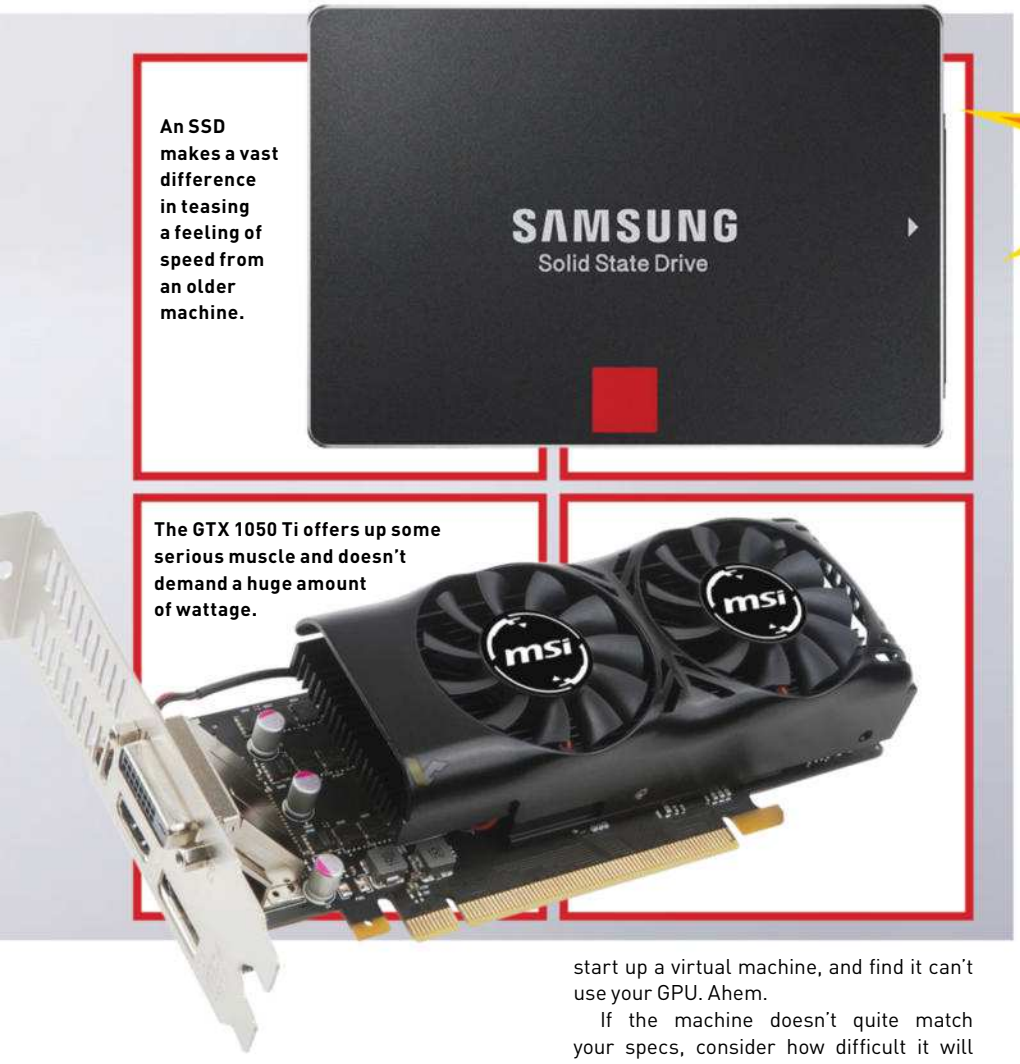
There are several avenues to follow if you're looking for an ex-lease PC. First, eBay, which is a vast repository of older hardware. Use all the tricks. Filter by the specific level of CPU you're looking for, by machines with 8GB RAM, to save you upgrading later on, and by the machine's designation—look for "refurbished" rather than "used." Check the listings. Scour through them, and read the descriptions; if a seller hasn't even bothered to check out the specs of a machine and type out an informative listing before trying to flip it online, they don't deserve your business. Amazon is a good place to look, as many resellers lurk in its underbelly, but prices tend to be a little higher there

Perhaps the best option is to seek out a recycler or reseller close to you, or go to the source, like a local office IT department. If you can see a machine working before you buy it, all the better, and collecting yourself reduces cost and negates potential shipping nightmares. Nobody wants to receive a PC in several pieces.

Wherever you shop, be frugal. We can't tell you precisely what to pay, because that depends on your budget and what's floating around at any particular time, but saving a buck or 20 is the whole point of this exercise. Don't dodge a bargain just because it looks too good to be true. The second-hand market is volatile, and different sellers have wildly varying ideas of the value of their stock. Perusing eBay quickly reveals the sort of prices you don't want to pay.

Essential questions

There's a stack of potential pitfalls that come with buying a second-hand machine, some of them avoidable, some of them not so much. Let's start with Windows; make sure you get a machine with a legitimate install on board, and preferably one with



An SSD makes a vast difference in teasing a feeling of speed from an older machine.

The GTX 1050 Ti offers up some serious muscle and doesn't demand a huge amount of wattage.

the COA sticker still glued to the PC's case. You'll likely come across a lot of hardware that originally ran Windows 7 or Windows 8.1—ensure from the seller that the key on the box has been properly transitioned to Windows 10, and is the same key used in the install on board. A legal copy of Windows 10 forms a big part of the value of these machines; often they can be found for less than the cost of a retail Windows 10 key.

Next, ensure that the PC you're buying can do what you want. This means a whole lot of research before handing over your cash. Dig up the original datasheets, look at images online of the case opened up, research every last detail. If the PSU is proprietary and offers little to no overhead, steer clear. Maybe it's fine, but the PCIe slot can't supply enough power to juice up a decent GPU. Perhaps, as we learned to our peril when purchasing our example machine, the CPU supports VT-d instructions, but the chipset on board the proprietary motherboard does not. Thoroughly list your requirements and check them off one by one—don't miss any, or you'll shed a tear or three when you go to start up a virtual machine, and find it can't use your GPU. Ahem.

If the machine doesn't quite match your specs, consider how difficult it will be to bring it up to speed, and whether it's worth stepping up, or buying cheap, then upgrading later. You could, for example, save a little hassle buying a PC with 8GB RAM or more, but check the prices of upgrades, and compare them to machines with less RAM. Just as there are stacks of these machines on the market, there are stacks of components from machines that have been parted out for profit; go back to those copious notes you made to ensure that what you're buying is compatible.

Aftermarket upgrades

A little extra RAM is essential, and it's just the tip of what you can do to these machines. You'll want to do all you can to compensate for the inherent weaknesses of an aging office PC, particularly the processor being a few steps back from cutting edge. But, alas, you'll likely be working with a very limited platform. So what can be done?

First up, grab a SATA SSD for the operating system. It doesn't have to be huge or outrageously fast, but you must buy new—who knows what hellish barrage of read and write cycles a used one has

BEST BUDGET BRANDS

Three manufacturers are responsible for the majority of office PC supply: Dell, HP, and Lenovo. Dell's Optiplex line is the one you'll see most often, and its ubiquity means it's usually the most reasonably priced. Look to pay around $100 for an Optiplex 790 packing a second-gen Core i5, or $10–$20 more for an Optiplex 7010 with a third-gen chip. The internals are great to work with, and they're covered in USB ports. And that pierced gray accent panel? That's actually pretty nice.

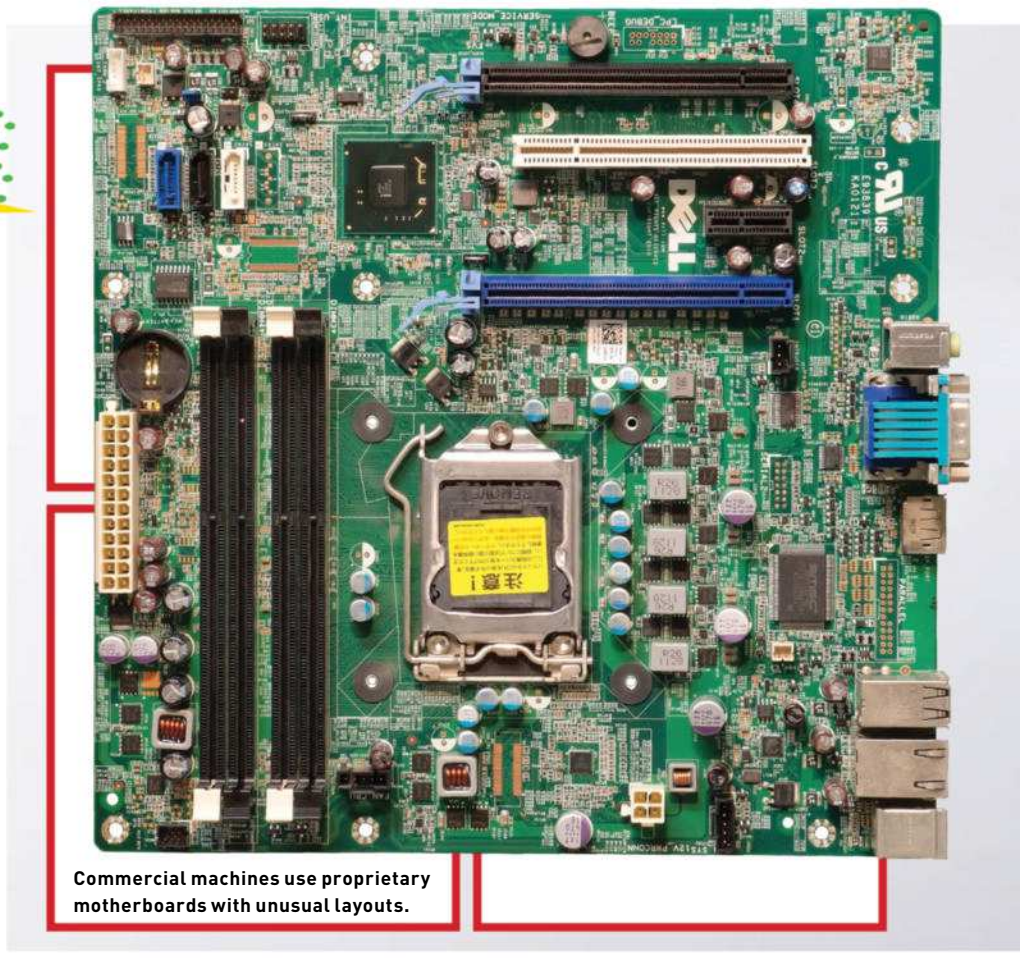
Next up, HP, and its sub-brand Compaq. If you can find an HP ProDesk (the model we bagged while researching, for around $170), you'll get at least a fourth-gen chip, although the smaller form factor models are so tightly configured they're not worth your time if you're planning to upgrade. The Elite line is generally a great deal, at around $110 for an Elite 8200 with a Core i5-2400. Shop around, and you may be able to find the step-up 8300, with an i5-3470, for a similar price—cast scorn at those trying to get $400-plus for them, for they are fools.

Lenovo's ThinkCentre line is less common, and the more compact designs can be tricky to work with. If you do go for an Lenovo, the M72E tower, around $140, is a decent third-gen base with plenty of room within to work. Other brands do produce business machines, but can be hard to come by; Acer's Veriton line is probably the fourth most common commercial desktop, though your options are limited, and it's very rare to see AsusPro boxes on these shores.

FACTORING IN FORM FACTORS

The vast majority of ex-office PCs come in SFF—small form factor—cases. They didn't need to be gigantic for the job they were designed for, but it does mean you're going to have to think about what you'll be able to achieve. The case design is often fantastic for quick maintenance; generally hard drive and optical drive caddies are screw-free, the case itself opens in seconds, the RAM slots are easily accessible, and there's no excess wiring to worry about. But you're stuck with half-height cards, and it's imperative that you check the position of the PCIe slot before buying the PC or a graphics card. All too often, it's located in such a position that only single-slot-width cards work, and so close to the PSU or the side of the case that adequate airflow is impossible.

You may also see USFF PCs, even smaller than SFF. These aren't much good for us, as they don't have any space or slots for expansion. There's a way to add external graphics to them, sure: If you find the right cables, it's possible to string a wire from a mobo-mounted mini-PCIe socket to an external PCIe card slot. But don't buy a PC expecting to do this. It's impractical, awkward, and silly. Keep an eye on eBay listings—if one is dealing with multiple lots and says you may receive an SFF or USFF edition of a PC, walk away. Look for a tower case. The extra space makes them worlds easier to work with.



Commercial machines use proprietary motherboards with unusual layouts.

been through? Silicon Power's 60GB drive is perfect, a $25 upgrade at press time. Installing it isn't simple, though; you'll likely need a right-angle SATA cable due to case space considerations, and you're unlikely to get a 2.5-inch drive mount included with your machine. That's an extra you'll have to source independently. Mass storage may also be a potential upgrade, particularly if your machine comes with a measly capacity, as this category so often does. If you don't replace the spinning hard drive, consider it expendable: its lifespan will have been significantly reduced by wear over time.

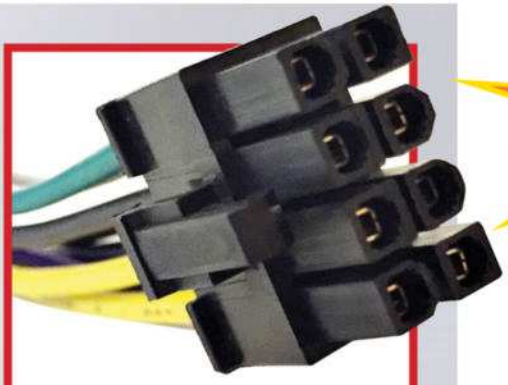
Next, think about whether you should upgrade the CPU, then look in your box of unused CPUs to see if you already have a willing victim. In our experience, buying a CPU to upgrade an office PC is a long way from being cost-effective. Usually, you'll find used CPUs on the market for around the price of a fully functioning machine. Bumping a Core i5 up to the equivalent Core i7 is something you should integrate into your original purchase, rather than doing as an upgrade, and given that the CPU is (weirdly) one of the least important parts of our budget build, it's not worth banging your head against eBay for too long while waiting for one to come up. They're not common—justifying the expense of a Core i7 on an office desktop is tough even for the highest-falutin execs—but they are out there.

The upgrade component that really gets an office PC cooking (perhaps literally, if you're short on case space) is a new GPU. This is, as you've likely guessed, the reason that buying an old PC for gaming makes any sense: That dated CPU might let it down, but the vast majority of modern games lean more heavily on graphics power than they do on the processor. You're building a PC with a known bottleneck, but one with surprising ability for very little money.

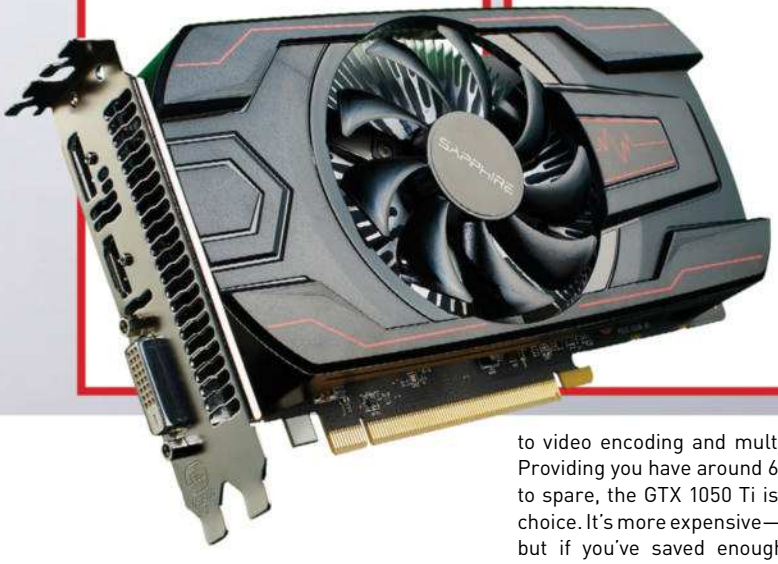
Graphics grunt

Unlike the other stock upgrades, it's important to cater your choice of card to the capabilities of your sourced hardware. If you've bagged an SFF case, you need to consider the space available (see "Factoring in Form Factors," left), while tower cases, however peculiar the motherboard may be, are generally flexible and roomy enough to house any card. It's not worth skimping on this aspect, particularly given that there's a limited number of cards that are suitable for use in this category—you are unlikely to find an office PC with a six or eight-pin power connector coming from its PSU. That's just not a thing that happens, so you need something bus-powered, drawing within

DDR3 isn't the fastest, but it's cheap and plentiful. Check the maximum capacity and available slots of your box before buying.



You'll likely need a converter if you use an off-the-shelf PSU with an office PC.



If you have the PSU capacity for an RX 560, a 4GB model will net you impressive graphical results.

PUT IT TOGETHER

So, you've got your PC home, and picked up any additional components you need. Don't rush into anything; this is a second-hand box, and you should treat it with suspicion. Contain your excitement, and inspect the internals thoroughly, making sure every cable is properly attached, and everything looks as it should before plugging in and powering up. Run the machine without your upgrades first, to ensure you won't fry any new components, then add them once you've stress-tested the base model for a while.

Depending on where you've picked it up, you may be forced to refurbish the PC yourself. This isn't difficult—it's just a case of giving it a good clean—though be prepared to take it outdoors with a can of compressed air, because something that's been running on a desk for five years is likely bursting with dust. Remove and hose down any heatsinks, allowing them to completely dry, to ensure they're as effective as possible. Replace the thermal paste on the CPU, and reseat everything to ensure a solid connection.

When you start up, check to see if Windows automatically logs on to an existing user account. If you're sent straight to the desktop rather than the first stage of Windows 10's setup process, your seller hasn't done their job properly. You're probably going to want to reset the OS and start from scratch, because that cut-price machine could well be serving as a trojan horse from an unscrupulous individual. You might never know if there's a keylogger—or worse—preinstalled in that user account. Resetting Windows should put everything back to defaults.

the limits of your PSU's remaining wattage, which cuts down the options somewhat.

Even the lowliest machine should be able to handle the Nvidia GeForce GT 1030. It's tiny, often available in low-profile half-height form, and there are versions, such as Gigabyte's fan-cooled $78 card, that have a single-slot footprint. Other variants include passive cooling, although this generally necessitates heatsinks that extend over more than one slot. Check not just the card width but its length, too—if you're dealing with restricted space at the end of the slot, something stubbier, such as MSI's Aero ITX ($118), would likely fit the bill. The GT 1030's key asset is both its price, which can dip below $70 if you look at the right time, and the fact that it demands only around 30W through the PCIe slot in order to power it. It may peak slightly higher, so make sure you have at least 45W capacity remaining on that PSU after the rest of the components are taken into account.

The GT 1030 can game, to an extent, and it's a great option if you want to keep your budget to a minimum, but it's better suited to video encoding and multimedia efforts. Providing you have around 60W PSU power to spare, the GTX 1050 Ti is a far stronger choice. It's more expensive—at least $200—but if you've saved enough on the base machine, you'll still bring home a box that packs some serious muscle for potentially under $300. There are smaller versions (check out the half-height MSI variant), 2GB and 4GB editions, and overclockable variants, but don't buy the latter expecting to push it too far. The GTX 750 Ti is another strong option, although since it's been retired, you'll need to unearth a used one.

On the AMD side, you could hunt for the RX 460, another card that's been canned, but it's a pricey option even second-hand. The RX 560, still in production and decently priced at around $140, is a perfectly powerful card, but it typically pulls the full 75W from the PCIe slot, so a 400W PSU is all but essential—a rarity in office machines. We're not saying Nvidia is your only choice but, in this context, it's probably the only good one.

When you've got it, you don't need a step-by-step tutorial; just slot it in. It's the easiest upgrade you'll ever do. And when your GPU is installed, you'll have a machine that's far greater than the sum of its parts.

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TECH PORN

1 SUCCESSFUL RESOLUTION

This beauty comes in at an impressive 3840x1080 total resolution. That gives a pixel density of 81.41 ppi, the same as a 27-inch 1080p screen, and a total pixel count of just over four million, enabling Samsung to drive the screen at 144Hz, too.

Samsung C49HG90

BACK IN 2016, Apple earned itself a reputation of being courageous when it first launched an iPhone without a headphone jack. But, let's be honest, that was a minor risk in the grand scheme of things. The whole device didn't pivot around that one feature. This? This is true courage. A bold step in a direction few asked for, and even fewer need. In the grand pursuit of perfection and innovation, pushing boundaries is central to the creation of new standards and further enjoyment. That said, such forays into insane design often remain mere concepts, never becoming full-fledged products. To bring a screen of this caliber to fruition costs hundreds of thousands of dollars. Forty-nine inches and a 32:9 aspect ratio truly is courageous, especially for a screen, and particularly one that costs $1,500. It's a gamble, a risk of the highest order, but it's paid off for Samsung. **–ZAK STOREY**

2 QUANTUM LEAP

There's quantum dot tech here, too, enabling HDR thanks to Samsung's combination of QLEDs and a VA panel. Unfortunately, there are no PLS or IPS variants, so color accuracy isn't as good as it could be, but it is the perfect match for gaming.

3 RESPONSIVE SYNCHING

How Samsung has managed to net a 1ms G2G response time out of a VA panel is beyond us, but the company has also paired it with some swanky FreeSync tech from AMD, again leaning on that gaming angle.

PERFECT BACKUPS

In a world ruled by the God of Clouds, surely backing up your system should be easy? We are here to show you that it is... *By Neil Mohr*

Backing up is the single most boring subject on the face of the planet; think watching paint dry crossed with 24 hours of Canadian curling in slow motion. Keep reading, though, because it's also quite possibly the single most important task you can do on your PC.

So, how can we make backing up sexy for the Millennials? The usual answer would be to add a little gamification, but as we're not app writers, that's not going to happen. Our next best answer is to make it easy, quick, and as close to being invisible as possible.

Part of the problem is that there's no immediate pay-off for using your valuable time to set up a backup regime. It's like dealing with climate change, the national debt, or car insurance: It's someone else's problem, isn't it? Until you total your automobile, or China wants its yuan back, or you're up to your ankles in flood water, or are having trouble finding somewhere to go skiing.

With a tiny bit of planning, backups can be made super-easy today. High-speed wireless, abundant storage, and access to free cloud storage options ensure you're able to back up your data in smart ways that protect your vital personal finances, documents, photos, and whatever else you'd like.

So, take 15 minutes out of your day and see how easy it can be. We'll offer up solutions from Microsoft, the best open-source options, and expand our search to full-system images, along with wider cloud options that can help you back up all types of media, often for free, and usually with little work involved.

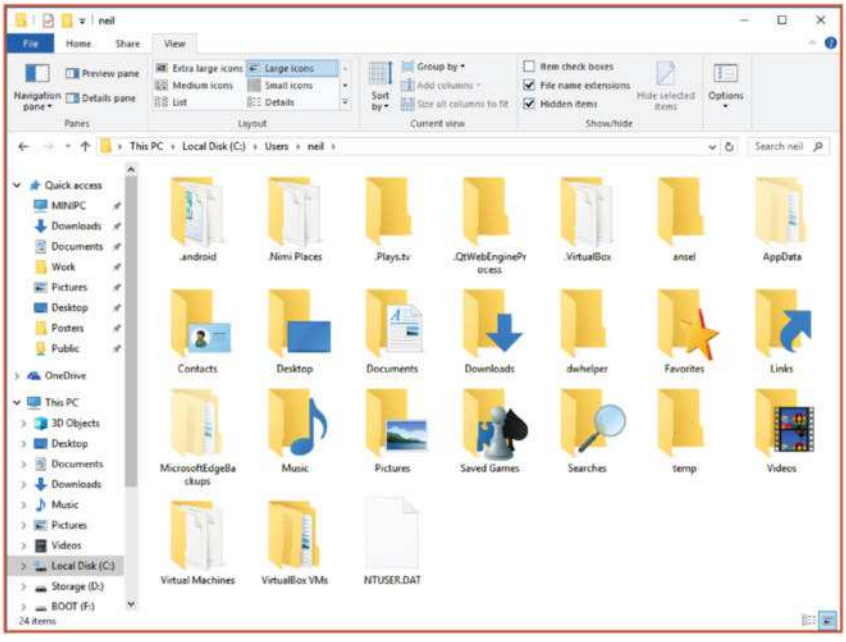
What is best in life? Obviously to crush your enemies, see them driven before you, and to hear the lamentations of their women. That's nice and all, but Conan never experienced the sweet, sweet feeling of restoring a lost file from a well-planned backup. There's a key adjective in there: planned. If you want to do backup well, it's best to plan a little, and there are two main areas you need to concentrate on: the source and the destination.

Let's start with the source. What on your computer is important to you? If your PC spontaneously combusted and melted into a pool of expensive steel and plastic, which files on there would be irreplaceable? You should probably plan to have these backed up. There are two main approaches: a brute-force entire-drive system image, or a more nuanced selective backup.

We're going to steer you away from system imaging, though we'll cover it later for completeness. The way we use operating systems, alongside changes in technology, have made system images less useful for personal backup. It's partly to do with deciding what is essential to back up. System software isn't essential, because it can be replaced. General software, too. Your Steam collection doesn't count either, because it can be downloaded again. See how it works?

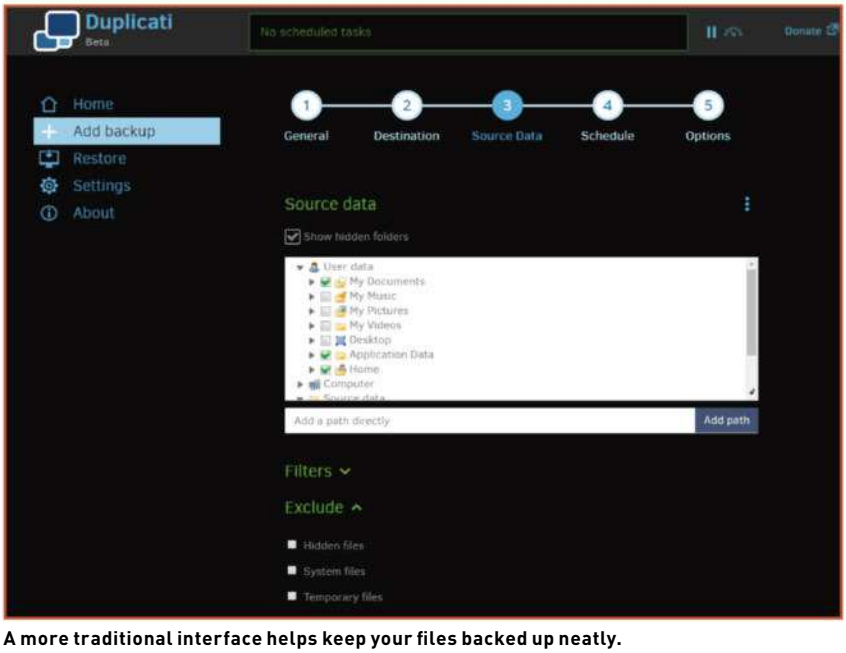
Photos of your newborn child, your financial documents, that video of Zak taking a tumble off his mountain bike, and anything you'd classify as work will likely be on your hit list of irreplaceable files.

Before you can back these up in any sensible way, though, you need to know where they're all stored. That's why, way back, Microsoft introduced the (My) Documents folder to store everything, and continued to expand this with relevant sibling folders, such as Pictures, Music, and so on. The idea being that everything that's important to you can be found in one of just a few folders.



What has he got in his pockets? We're going to plead the fifth on that one....

The dirty reality is that all of these default system folders are stored in the user's main system folder, typically under C:/Users/<user name>, alongside the Desktop contents, temp folder, any random program folders, and additional program settings under the hidden AppData folder. Typically, any default backup regime will save the entire folder for an individual user. If you're storing files elsewhere, you'll need to manually add these to your backup. Talking of which....

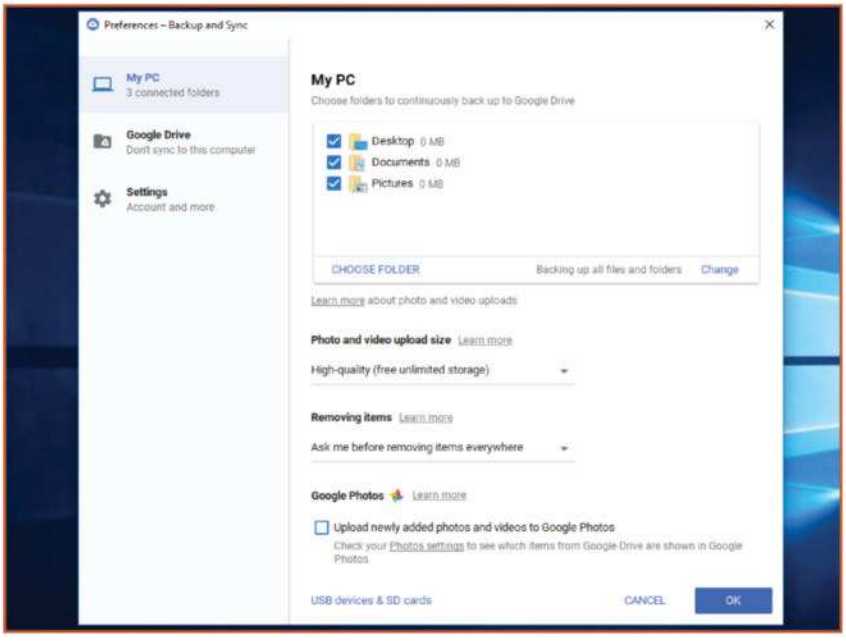


A more traditional interface helps keep your files backed up neatly.

Windows 8 (and onward) Backup uses the File History system, which is pretty neat, but isn't the smartest-looking thing to set up. It requires an external drive or network share to function—we'll get on to destination options shortly. Open the Start menu, type "Backup," and select "Backup Settings." If it's not configured, there will be a "+" symbol asking you to add a drive; once a drive has been added, this changes to a simple on/off toggle. The grown-up settings can be found in the traditional "Control Panel → System and Security → File History." If you want to add a network share, do it through "System and Security → File History → Select Drive → Add Network Location."

With a drive added, click "More Options." You can instigate a backup immediately here, and choose how often to perform the backup, and how long to keep it. Plus, you're able to remove any unwanted folders—as discussed, these are largely the contents of C:/Users/<user name>. Do you really want to include Downloads or everything that's on your Desktop?

The neat trick with File History is that once it's up and running, you're able to right-click any file, select "Properties → Previous Versions," and restore past versions that have been backed up. It's like System Restore, but for files. To do mass restores or rollbacks, open the Start menu,


Preferences – Backup and Sync
My PC
3 connected folders
Google Drive
Don't sync to this computer
Settings
Account and more
My PC
Choose folders to continuously back up to Google Drive
Desktop 0 MB
Documents 0 MB
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CHOOSE FOLDER
Backing up all files and folders
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Learn more about photo and video uploads
Photo and video upload size Learn more
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Ask me before removing items everywhere
Google Photos Learn more
Upload newly added photos and videos to Google Photos
Check your Photos settings to see which items from Google Drive are shown in Google Photos
USB devices & SD cards
CANCEL
OK

Options. We love options. And there are plenty when it comes to backups.

type "Restore your files," and open the Control Panel setting. Just select the folder or files you'd like to restore, and off you go!

ALTERNATE OPTIONS

Of course, if you find the default Windows system too basic or unappealing in general, the world of software has a host of other options you can choose from. We're going to suggest two worth your time. The first is Duplicati (www.duplicati.com). This is a fine upstanding LGPL-licensed open-source, cross-platform straight backup application, which supports a wide range of local and cloud targets. If you have to deal with other systems, it's handy to know that your backup client can deal with Windows (64 and 32-bit), MacOS, and Linux (Deb and RPM packages), plus there's a Synology NAS build, too.

By default, Duplicati offers a serviceable browser-based interface—thankfully with a Dark theme option—giving away its more powerful features. There is a command-line version, too, for those who fancy weaving it into their PowerShell scripts.

What's of real interest with Duplicati is the wide range of supported backup targets and protocols. There's traditional (S)FTP/SSH and WebDAV, and then, more useful for a newer generation, a bunch of common cloud services, including Amazon S3, Microsoft Azure, Box, Dropbox, Google Drive, Mega, and so on.

If you're wondering why Windows network shares aren't specifically listed here, fear not: When choosing the destination with "Local Folder or Drive" selected, click the "Manually Type Path" option. You need to enter the server name and path to the networked backup folder, plus add any required login details in the username/password boxes below this. The standard format is "\\<servername>\<path>." If you're not sure, open up File Explorer, browse to the remote server folder, then click in the address bar—Windows then helpfully displays the raw address, which you can copy and paste into the box. Ensure you use the "Test Connection" button before moving on.

That's the basics of this powerful little tool, but don't overlook the little extras, such as bandwidth throttling in the top-right, plus additional settings to filter files based on size and system attributes.

We should mention another backup tool: the worthy SyncBackFree, part the SyncBack range by 2BrightSparks (www.2brightsparks.com). The SyncBack range is immensely powerful, and even the free version—limited to FTP and local networks—can become overwhelming with its available options. What SyncBack offers over Duplicati, alongside standard backup, are Sync and Mirror modes. Synchronization isn't true backup in the technical sense—we're not going to get into

RAID IS NOT BACKUP

Simply running RAID on your desktop system is not backup. A backup is a separate copy, stored on a separate system, and ideally you have another copy offsite. You can follow the line of disaster: If your main system explodes, you have a backup on your spare system; if that system explodes, you have a copy on your main system; but if your home explodes, you have a copy offsite. Enough exploding.

What RAID is great for is redundancy, and as we all know, redundant systems are there to increase system reliability through duplication of functions.

In the case of RAID 1, 5, and 6, an entire drive can fail, and the parity (or mirror) the system uses can enable it to recover the local data. RAID 5 can handle a single drive failure from three or more drives, while RAID 6 can handle two drives failing running with four drives or more—this was added because the time to rebuild large arrays inevitably increases the window of opportunity of a second drive failing.

What RAID doesn't do is create a backup, so if the entire RAID fails—and it does happen—you lose all your files, and recovering data from a RAID is a huge pain. It also doesn't necessarily protect against bitrot—the undetected deterioration of digital data on a storage medium. Advanced filesystems, such as ZFS and Btfs, offer checksum protection, but these aren't a realistic option for Windows users. So, we're back to suggesting you need a real backup to secure data safely.

FREE YOUR CLOUD

Here at *Maximum PC,* we wouldn't describe ourselves as cheapskates, but you're more likely to find editor Alan sprinting off home at the end of a working day, rather than risk the chance he has to pick up a bar tab *[hey!—Ed].* There is certainly a number of free cloud services that we recommend you could consider for backing up specific types of files, which offer a useful offsite alternative and other services. However, if data is truly precious to you, we strongly recommend you consider paying for a suitable service—if a product is free, then you're the product.

To kick things off, Google Photos offers unlimited free photo storage when you opt to use its "compressed" service. Google has done a ton of advanced research into image compression, and you're not likely to spot any difference. It also offers free 1080p video storage for clips under 30 minutes. It's suppose to tie in with Android device usage. A solid alternative is Flickr, now owned by the non-hacked SmugMug, rather than Yahoo, and you get 1TB of storage, which is not to be sniffed at.

Spinning back to Google, Google Play Music offers storage for 50,000 tracks for free, if you're happy to be annoyed by promos to pick up its paid-for unlimited service now and again. It supports MP3, AAC, WMA, FLAC, Ogg, and ALAC, and individual tracks can be up to 300MB in size. There's a desktop uploader tool, which can churn away, uploading in the background.

For straight storage, the go-to free service tends to be Mega.nz, which provides 50GB of free storage via its pretty slick desktop and mobile systems. You then have a host of services such as Box, pCloud, and MediaFire, which offer around 10GB for free, with paid-for options on top, alongside what Microsoft OneDrive and Google Drive have to offer.

that here—but if you're after a solution with more flexibility, SyncBack is worth a look.

If you want to implement a quality local backup system, you need a reliable way to store your files. You could just plug in any old USB drive, and use that as a backup—there's nothing explicitly wrong with that, and it's certainly better than nothing. The chances of both your desktop and the USB drive failing are slim, unless there's a fire, flood, or other act of god. An external device with RAID 1 would be our next favorite; there's a wide range of desktop drives that offer dual-drive support with mirroring—this enhances your backup with redundancy, and should service most home users. The next step up would be an entry-level NAS box, which has the advantage of always being available, and supports additional services, such as being a cloud-based offsite uploader. It also makes its location more flexible, because Ethernet runs can easily be up to 300 feet, so you could stash it elsewhere in your home.

INTO THE CLOUD

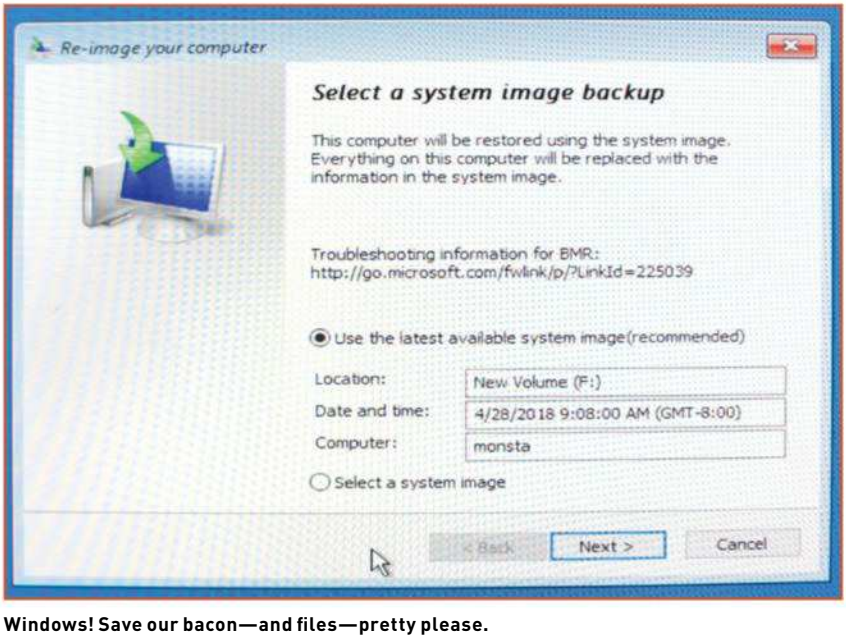
If you're looking for the perfect backup trifecta, the final vertex is offsite backup. For most people, this means a cloud-based third copy of any files, photos, or other settings. Cloud storage has gone crazy over the last decade, and transformed into a multi-billion-dollar business. If you need major offsite backup, there are plenty of cloud options to choose from, such as Amazon S3/Glacier, Rackspace, Microsoft Azure, IBM, Oracle, and more.

Those are designed more for enterprise-level backup, though, and we need to concentrate on straightforward consumer-level solutions that bundle the cloud storage with a desktop sync tool. Microsoft helpfully—and without any ulterior motive—includes its OneDrive tool with Windows. This very handily automatically offers cloud synchronization for anything stored in the OneDrive folder. Dive into the OneDrive Notification icon, and you can extend this "backup" protection to the standard Documents, Desktop, and Picture folders, too. As long as your precious files are stored here, you're going to have potential cloud backups of them as well. Microsoft offers 5GB of storage for free, while 50GB costs $1.99 per month, or if you sign up for Office Online, it throws in 1TB for $69.99 per year or $6.99 per month.

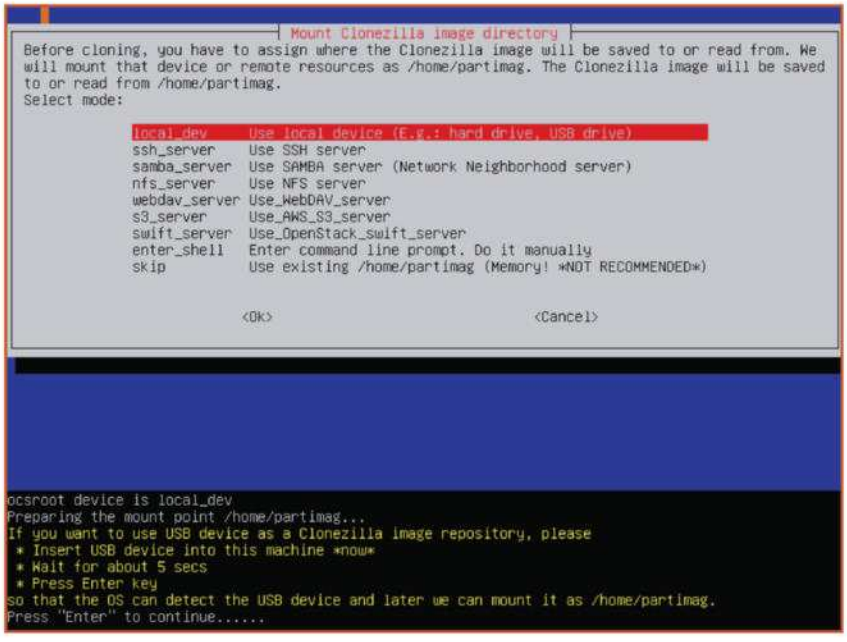
If you're locked into the Google ecosystem, you'll likely want to try the Google Backup and Sync tool (www.google.com/drive/download). It's a touch more flexible than Microsoft OneDrive for the simple fact it includes the option to add any folder to be synchronized with your account. As we mention in the "Cloud" boxout (see left), it also includes the ability to upload photos and utilize unlimited storage for these, if you use its compression program.

SYSTEM IMAGES

It's a time versus effort calculation: the time it takes to make and restore an entire system image versus installing from scratch. While it might sound faster, remember that there will be a host of updates and patches that will need to be applied, and a fresh install can handle that far more smoothly. Microsoft tried to push people away from system images when it introduced Windows 8, by entirely killing


Re-image your computer
Select a system image backup
This computer will be restored using the system image. Everything on this computer will be replaced with the information in the system image.
Troubleshooting information for BMR:
http://go.microsoft.com/fwlink/p/?LinkId=225039
Use the latest available system image(recommended)
Location:
New Volume (F:)
Date and time:
4/28/2018 9:08:00 AM (GMT-8:00)
Computer:
monsta
Select a system image
< Back
Next >
Cancel

Windows! Save our bacon—and files—pretty please.


Mount Clonezilla image directory
Before cloning, you have to assign where the Clonezilla image will be saved to or read from. We will mount that device or remote resources as /home/partimag. The Clonezilla image will be saved to or read from /home/partimag.
Select mode:
local_dev Use local device (E.g.: hard drive, USB drive)
ssh_server Use SSH server
samba_server Use SAMBA server (Network Neighborhood server)
nfs_server Use NFS server
webdav_server Use_WebDAV_server
s3_server Use_AWS_S3_server
swift_server Use_OpenStack_swift_server
enter_shell Enter command line prompt. Do it manually
skip Use existing /home/partimag (Memory! *NOT RECOMMENDED*)
<Ok>
<Cancel>
ocsroot device is local_dev
Preparing the mount point /home/partimag...
If you want to use USB device as a Clonezilla image repository, please
* Insert USB device into this machine *now*
* Wait for about 5 secs
* Press Enter key
so that the OS can detect the USB device and later we can mount it as /home/partimag.
Press "Enter" to continue.....

Ahh, text-only interfaces—we miss thee not.

off the long-standing, tried and tested Windows 7 Backup and Restore.

It's a fine system that created an image of the system drive on a local drive, network share, or a series of DVDs via shadow copy—so you could continue working on the system. It was "easy" to restore this image via the default system rescue disk, which you're prompted to make when an image is completed, and you very much should do.

After much wailing and gnashing of teeth, Microsoft thankfully restored the system to Windows 8, and it remains tucked away in Windows 10 under the traditional Control Panel section in "System and Security → Backup and Restore (Windows 7)."

A limitation with a Windows system image is that there are no options: It images the entire system drive, and you can't restore individual files. It also only backs up to the root of a selected drive, while it insists on a network username and password for network shares—even if it has public access rights. In this case, you need to provide the remote system's standard username and password.

Windows also offers an option to create a bootable recovery DVD, with which you can restore the system image. We strongly suggest you create one, because in the past we've had headaches attempting to restore images that differ from the installed version of Windows. Label it clearly, and store it somewhere safe alongside the system image.

To recover your PC, you have two options: one is to reboot using your recovery DVD, the other is to start Windows in Recovery mode. If Windows can run, open the Start menu, type "Recovery," choose "Recovery options," and select "Restart Now" under "Advanced Startup."

Choose "Troubleshoot → Advanced Options → System Image Recovery." Windows then reboots into its Recovery mode. You need the drive with the system image on plugged into your computer. Follow the prompts, and your system image will be restored.

There is a Linux-based open-source project called CloneZilla (back when everything was called <name>zilla) that we're a little hesitant to recommend. It's more flexible than Windows Backup imaging, in terms of your absolute control in what is imaged and how it's stored, but it's less convenient—because you have to boot a live disc—and, more annoyingly, it's tediously convoluted in that way that only Linux types can manage. If you're not put off by drives being called sda, and partitions being sda1 or sda2, it makes getting a drive imaged or cloned easier. Depending on what your definition of "easy" is.

Now you know how to get everything backed up, cloned, imaged, and sent into the cloud with as little hassle as possible, do it!

BACKUP THEORY

Not all backups are made equal; there are different types of "backups" depending on what the approach is and what the aim is. The type of backup can alter the type of transfer and how it's stored, so it's worth having a quick blast through the approaches.

We've been largely concerned with active backups in this article, so it makes sense to cover those first. As the name suggests, these are duplicate files of actively used system or data files. These contrast with archive backups, which we'll cover shortly. An active backup attempts to back up all files, and then maintain an up-to-date version or versions of these according to a schedule selected by the user.

Archive backups differ from active ones because they're only concerned with data that's no longer actively used, but copies are required to be retained. They're essential for businesses, but also for individuals who want to safely retain financial or legal records, message logs, and so on. They require a different approach to that of active backups in terms of reliable long-term storage.

Synchronized files are a modern spin on the active backup, and enable a file to be accessed from any location, or remain the same in multiple locations. Dropbox is a classic example, but modern "office" services, such as Google Drive, provide something similar, with multi-user access and versioning.

Synchronized services typically require an Internet connection to run the backup and be accessed, unless a local service is being run, such as OwnCloud or Nextcloud. An active backup is best run over a local network or wired drive, though for more limited purposes, a cloud service would be adequate. You would want to consider redundancy on the backup medium, such as RAID. Archives would ideally be stored offsite—a cloud service would be ideal—and if the data is irreplaceable, a bitrot-aware filesystem, such as ZFS or Btfs, would be advisable.

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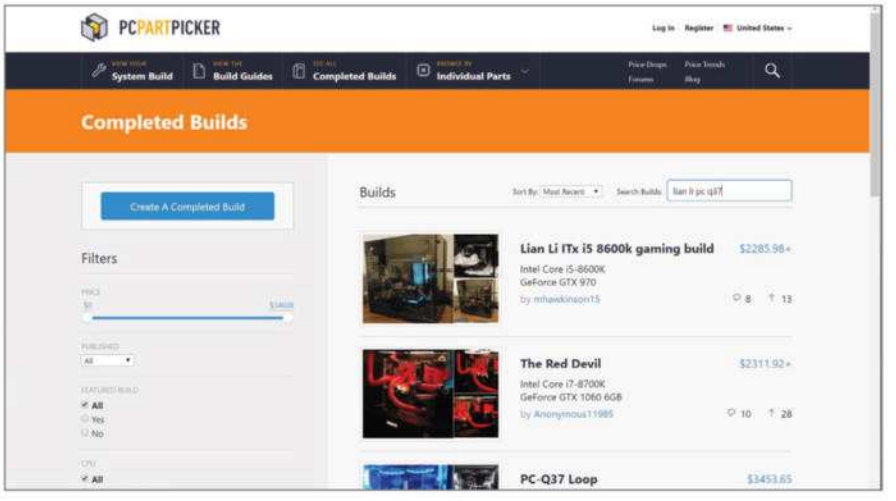
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH



BUILD INSPIRATION

From the most basic budget build to the highest of the high end, all rigs require inspiration and planning before you jump in. For top-end systems, PCPartPicker is your friend. The best way to see what you can do with a chassis is to go to PCPartPicker's "Completed Build" section and type in the case that you intend to build in—the website then gives you a good idea of what you can do with it. www.pcpartpicker.com

MAKE – USE – CREATE

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ZAK STOREY
DEPUTY EDITOR

GOD DAMN IT, MICROSOFT!

I'm going to come right out and say it: Microsoft should have charged for Windows 10. I'm not talking about today, because now, of course, you do have to pay for a legit license. But the free upgrade over the first 12 months? That shouldn't have happened.

I stand by this for a number of reasons. First and foremost, we have to ask why Microsoft did it. Don't color me ungrateful, but how did the big M make as much money from the free upgrades as it did from those who moved up 12 months later? Free advertising? Buy Office 365 today? *Candy Crush?* All we know is that it's the biggest OS out there, thanks in part to that free initial courtesy upgrade.

Also, I'm worried that this idealistic shift to a free OS has changed Windows to something more akin to Apple's locked-down MacOS than the legendary open platform that it was.

My biggest gripe, though, lies with the new "auto-reopen programs on shutdown" feature, something MacOS has had for a while. Shut down your machine, and on restart, every program, including Skype, Steam, and Chrome tabs, reopens. You now have to manually close these programs individually, before shutting down.

It's a frustrating and unwelcome addition to the shutdown dance. According to Microsoft, the feature is baked into the OS, and is impossible to disable, which simply sounds insane.

↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

Huawei P20 Pro

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products.
To learn more, visit www.ifixit.com.

The three rear cameras alongside the front-mounted "selfie" camera give you plenty of options.

Be careful not to damage this cable when you do get inside; it's just short enough to accidentally destroy.

BACKGROUND

Huawei is angling for the high-end segment with its three-eyed raven P20 Pro. It has packed a ton of tech in here, what with three cameras, plus a 24MP selfie cam—all topped off by a notched display. Hate it or love it, we're tearing it down.

MAJOR TECH SPECS

- 6.1-inch OLED touchscreen with 2240x1080 (408 ppi)
- Octa-core Kirin 970 with Mali-G72 MP12 GPU, and a dedicated NPU
- Triple-camera 40MP + 8MP + 20MP, f/1.6 and f/2.4 main camera unit by Leica
- 24 megapixel (no, that's not a typo) f/2.0 selfie camera
- 128GB storage and 6GB RAM
- Android 8.1 Oreo

KEY FINDINGS

- Huawei has opted to notch the display of the P20 around its camera and earpiece speaker. Compared to its predecessor, the P10, this new Huawei comes with some beefed-up dimensions: 6.10 x 2.91 x 0.31 inches and 180g in weight. It also boasts three cameras on the back. The 40MP and 8MP cameras work together to get a 3x optical zoom. The 20MP monochrome camera brings extra detail and sharpness.
- But enough about the outsides—in teardown land, it's what's inside that counts. Eliminating pesky pentalobes was a welcome move, but no screws at all? Time to try our luck with the trusty iSclack. To our surprise, the P20 Pro opens almost as easily as a flower in the spring sun. Almost. We've never had to use an opening pick on a flower. This teardown is really starting to bloom, look at all that techy nectar—er, is this metaphor getting away from us?
- We go to remove the back cover and are foiled! No fingerprint scanner back here, and there's still a cable primed to be ripped during opening—looks like Huawei opted to mount the laser autofocus sensor on the rear case to stack it over the cameras. We finally get our hands on some screws and make quick work of the NFC antenna and motherboard shield.
- Finally, we come to the brains of this operation—the motherboard—and wrestle it free from its various connectors. Huawei once again sticks to its usual motherboard design, opting for a wider battery and a smaller board than some other Android phones. The trio of cameras comes along for the ride, holding fast to the board, with the rear flash module in tow. The three rear cameras get by with just two connectors—the main camera and the monochrome camera share one port, while the telephoto camera gets the other all to itself.
- Usually, we don't like barriers between us and battery replacements, but we might make an exception for the modular charging port. That'll be a painless replacement. Since we got this far without heat, we stay cool and attack the battery glue with some drops of magic. Wait just a tick—then, opening pick. As smartphone batteries go, this one's a heavyweight—4,000mAh at 3.82V, or 15.28Wh.
- Repairability Score: 4 out of 10 (10 is easiest to repair). Many components are modular and can be replaced independently. Replacing the battery is possible, but at the expense of some time and effort. Double the risk of breakage with glass front and back. Replacing the screen requires going through at least two layers of adhesive and some disassembly.

Build Your Own Pi-Powered Robot

YOU'LL NEED THIS

RASPBERRY PI
The new Raspberry Pi 3 Model B+ costs just $35.

ROBOT KIT
We're using the DiddyBorg from ModMyPi, but other kits are available from different suppliers.

ROBOTICS NEEDN'T BE about building intimidating humanoid automatons. We can build machines that can perform all kinds of other useful, instructive, or fun functions. Even better, you can power them with Linux.

You won't need costly electronics to build these devices. A Raspberry Pi will do just fine. It doesn't need to be any more advanced than constructing a Lego set, either. There are plenty of off-the-shelf kits suitable for any budding electronics enthusiast.

We'll reveal how to put together your own roving robot, and show you a couple of neat Python programs to get you started. And if you're feeling more adventurous, then why not build your own robotic helpers from scratch? All the components are easy to get hold of, thanks to the growing maker community.

If you want to take it to extremes, 3D print your own custom parts, and add some pseudo-sentience to your creation with some machine-learning voodoo. Or build your own robotic pet and have it follow you around like a puppy. The possibilities are endless. So power up that Pi, get yourself some components, and let's start hacking some robots together. –JONNI BIDWELL

A

1 INTRODUCING THE DIDDYBORG

The good people at ModMyPi were kind enough to send us a DiddyBorg v2 to play with. We're eternally grateful for this, and we thoroughly recommend you check out their store next time you need anything Pi-related.

›› The Borg series was designed by PiBorg, brainchild of Timothy Freeburn, who explains, "The DiddyBorg [**Image A**] is a six-wheel drive robot, and is a homage to the Sojourner Mars Rover." PiBorg teamed up with ModMyPi back in October 2017. Jacob explains this collaboration: "Tim and I were both around during the genesis of the original Raspberry Pi B. Where I was off making cases, Tim was designing motor-controllers and LED thingies (www.piborg.org/ledborg/), so when ModMyPi developed into wider reselling, Tim's products were some of the first that we picked up."

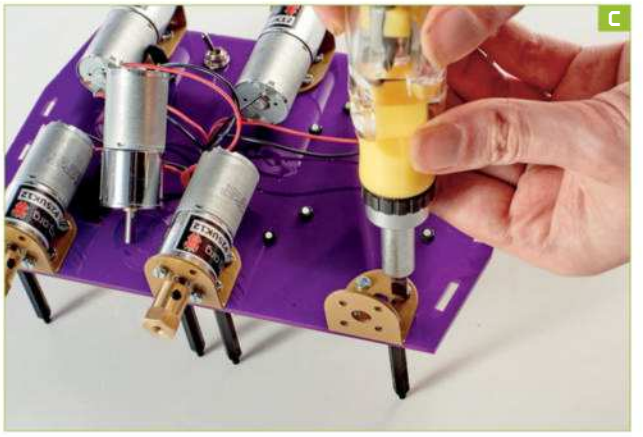
›› He continues: "As the market has progressed over the years, we realized the need to bring in more in-house development, and Tim realized the value in utilizing our distribution network for his products. He could devote time to making more cool stuff, and we could devote more time to selling and sending. We both work well at our respective goals and get along, so it was a no-brainer to team up!"

›› Our DiddyBorg ($294 plus international shipping at approximately $15, from www.modmypi.com) features six powerful 12V 100rpm motors, and is powered by 10 AA batteries. Power is distributed by the custom ThunderBorg board, which can handle 5A per motor, has a multicolor LED (useful for monitoring battery status), and we're sure you agree really looks like the business. Rather than using some complicated servo arrangement for steering, the DiddyBorg rotates by turning its wheels at different speeds.

2 BUILD YOUR BOT

The Borgs (see "The Borg Series" boxout on page 61), and many other robots, are sold as build-it-yourself kits. Depending on the particular kit, this might be quite an involved process, involving small parts, soldering, and possibly a modicum of cussing. Building the DiddyBorg takes a couple of hours from start to finish, and you can find instructions at www.piborg.org/blog/build/

B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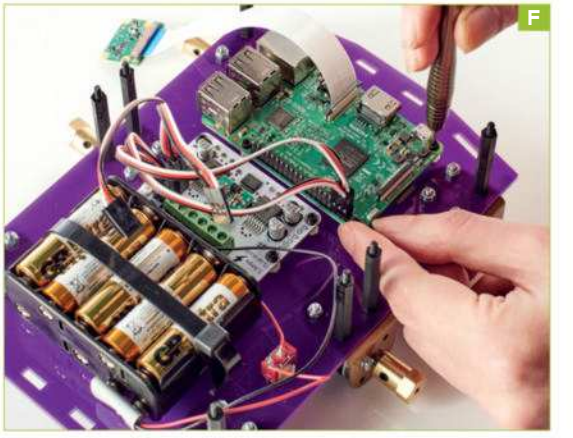

F

diddyborg-v2-build/diddyborg-v2-build-instructions. It would be silly to reproduce these in their entirety here, but read on for our general step-by-step robot building guide. We've based it on the DiddyBorg, because we have one, but construction of other robots will follow a similar prescription.

» If you can, it's a good idea to set up your Raspberry Pi as best you can before starting the build. Of course, it's possible to SSH to the robot once it's built to tweak things (so long as you've told it about your wireless network beforehand), but heavy wireless usage will sap battery power that could otherwise be used for careening around the office, annoying lesser magazine teams. If you have another Raspberry Pi and nimble fingers, then you can extract the SD card post-construction, and perform any tweaks on the other device.

3 ORGANIZE YOUR WORKSPACE

We know how tempting it is to just dive right in, and spill the contents of all the bags over your already messy desk. Don't do this. Instead, clear a nice workspace, read all the instructions carefully, and place all the tools you'll need to one side [**Image B**]. If you have to solder anything, make sure this happens in a well-ventilated area, and have some desoldering wick to hand.

4 FIX THE MOUNTS

The motors usually attach to the underside of the chassis by way of some angled brackets. Find the correct holes, and attach these brackets with the appropriate nuts and bolts [**Image C**]. If you're building the DiddyBorg, you'll find it uses metal posts to secure the brackets. Don't forget to add washers if your chassis needs them. These help to distribute force, and will protect against chassis fractures.

5 ATTACH MOTORS AND CONTROLLER

Fix the motors in place with the appropriate screws [**Image D**]. The DiddyBorg uses spring-lock washers to ensure friction even if the holding screw is loosened. You really don't want your motors detaching while your robot is in motion. Now attach the motor controller to the chassis, or attach any required standoffs and then do so. Pay attention to the controller's orientation here.

6 SOLDER AND ATTACH

Cut the required lengths of wire and strip the ends. We can't tell you how to solder from the confines of this small walkthrough, so be careful. Solder the red wires (if appropriate) to the positive sides of the motors, and the black ones to the negatives. Use a piece of tinfoil to catch any drips and protect the chassis. Connect the wires to the appropriate controller terminals [**Image E**].

7 ATTACH YOUR PI AND BATTERIES

Affix the battery pack and switch to the chassis, then connect them to the controller. For more powerful robots, this might involve heavy-duty wiring compared to the motors. Ensure that the SD card is in the Pi (and Raspbian is set up to use your wireless network and Bluetooth controller), and attach the Pi to the chassis. Take care not to overtighten the screws [**Image F**].

8 FINISH THE JOB

Connect the controller to the correct GPIO pins on the Pi (ensure that the connectors are oriented correctly). Attach any other robot peripherals (such as

G

sensors or cameras). Fix the wheel hubs to the motors securely with grub screws, and check that there's sufficient clearance for them to turn freely. Finally, put the wheels on the hubs and screw them firmly in place [Image G].

9 KEEP YOUR ROBOT BUSY

Having constructed our Diddy, we wanted to know more about what it could do. Not content with making glorious hardware, PiBorg also provides some great code examples to get you started. These will need some tweaking to work on other hardware, but should give you some idea of how to talk to the hardware in Python.

» Robot kits provide scripts to deal with all the low-level communication. In our case, this is all done through the ThunderBorg.py file (see www.piborg.org/blog/build/thunderborg-build/thunderborg-examples). This handles all the raw I2C coding, so you don't need to worry about that, and provides much more human-friendly functions, such as `SetMotor1()`, which sets the speed of the left-hand wheels.

10 WEB CONTROL

Assuming your Pi is connected to a wireless network, one slightly roundabout way to control it is to have it run a small webserver with an HTML form to control it. If your robot has a camera attached, too, you can stream the video to this webpage for a delightful first-person video driving experience.

» Creating a streaming video processor in Python is less complicated than you'd think, but more complicated than we'd like to get into in this summary. So, study the DiddyBorg web UI example at www.piborg.org/blog/build/diddyborg-v2-build/diddyborg-v2-examples-web-ui to see how the magic happens. If you're are lucky enough to own a DiddyBorg, copy that script to it.

11 GAMEPAD CONTROL

Controlling your robot with a gamepad is a little easier to get along with. However, as we discovered, they might need a little persuasion to work together when a GUI isn't running (such as when your Pi isn't connected to a monitor). In theory, you could set this up beforehand, or by removing the SD card from the robot, and booting it in another Pi—the settings should be remembered. If not, we can set this up by SSHing into our robot.

» There are two challenges to overcome: the actual Bluetooth pairing, and the subsequent setting up of the device nodes. The latter is handled by the "joystick" package (or "evdev," which it depends on), and the former by the `bluetoothctl` command (this is installed as standard). After installing the "joystick" package, run `bluetoothctl`. This starts a console, where we can scan, pair, and connect our controller. First, put the device in pairing mode, then initiate a scan with `scan on`. You should see a list of all nearby Bluetooth devices [Image H], along with their MAC addresses. Hopefully, your controller is in there, in which case, copy the address. Deactivate the scan with `scan off`. Then pair with `pair <MAC address>`, connect with `connect <MAC address>`, and take your leave with `exit`.

» Now run `evtest`, which greets you with a list of detected input devices. Select your desired controller and mash the buttons. You should see a different cryptic response for each button. The DiddyBorg includes an example script for joypad control, which uses the PyGame libraries to listen for the relevant button events.

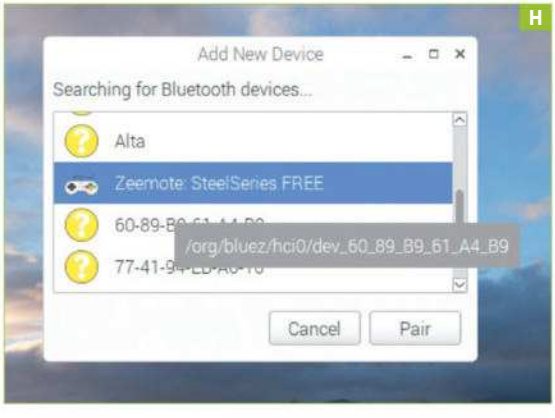
12 IMAGE RECOGNITION

If you know much about machine learning, you might have come across the idea of running Tensorflow on the Pi [Image I]. This is all thanks to the work of Sam Abrahams, who has provided precompiled wheel files for Python 2.7 and 3.4. This is good news if you're running the second-to-last (Jessie) version of Raspbian, because that includes Python 3.4. If you're running the latest version (Stretch, which uses Python 3.5), however, you'll need to use the Python 2.7 file.

» Having two different major versions of Python like this is fine (Raspbian ships them both as standard), but one cannot have 3.4 and 3.6 installed concurrently, and the 3.4 wheel won't work with Python 3.6. Before we begin, be advised that the Tensorflow models repository is large, and more than once we ran out of space using an 8GB SD card. This can be worked around by removing larger packages, such as LibreOffice and Wolfram Alpha, but using a 16GB card is recommended. The following commands set up everything you need:

```
$ wget https://github.com/samjabrahams/tensorflow-on-raspberry-pi/releases/download/v1.1.0/tensorflow-1.1.0-cp27-none-linux_armv7l.whl
$ sudo apt install python-pip python-dev python-pil python-matplotlib python-lxml
$ sudo pip install tensorflow-1.1.0-cp27-none-linux_armv7l.whl
$ git clone https://github.com/tensorflow/models.git
```

» This last stage starts a roughly 1GB download, so beware. If you run out of space, the process can be resumed, once you've cleared some clutter, by running `git checkout -f HEAD` from the models/ directory. Once it completes successfully, test it with the following:



H

THE BORG SERIES

Resistance is futile. PiBorg's Borg series consists of three robots: the DiddyBorg ($294), the MonsterBorg ($294), and the YetiBorg ($224). The DiddyBorg's flat top makes it possible for all kinds of things to be mounted atop it. A terrifying robot claw, for example. It can be reconfigured with the Multifunction Top to fit an additional Pi, or with the Touch Top to fit the official Raspberry Pi touchscreen. It can also be fitted with front and rear Pi Cameras, as well as ultrasonic sensors for obstacle avoidance.

Then there's the MonsterBorg, a machine not to be trifled with. Its chunky four-inch wheels enable it to chew up off-road terrain. PiBorg organizes the Formula Pi racing event (www.formulapi.com), and racing is what the MonsterBorg does best. Its 3mm-thick aluminum chassis ensures that it can survive all but the messiest of crashes.

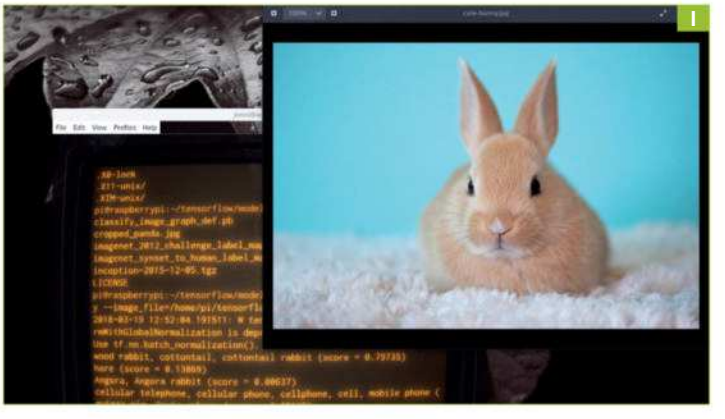
Finally, there's the nimble YetiBorg. Powered by a Pi Zero (included) and a single 9V battery, the YetiBorg uses the custom ZeroBorg motor controller. This enables independent control of its four motors. It can be assembled in two different configurations: low-profile and off-road. In low-profile mode, should it accidentally flip over, it's perfectly capable of continuing upside down. If a little more clearance is required, the off-road mode keeps the chassis clear of bumps and the electronics shielded from puddles.

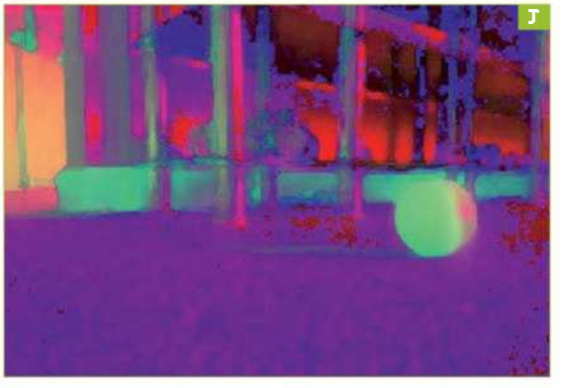
```
$ cd models/tutorials/image/imagenet
$ python2 classify_image.py
```

» This should identify the bundled panda image (which was extracted to /tmp/imagenet/cropped_panda.jpg). The script can also take an `--image-file` parameter to identify user-supplied images. So, with a bit of hocus-pocus, we could adapt things to take a photo, and then attempt to identify it. Since the whole process takes about 10 seconds on a Pi 3 (although this could be sped up by keeping the program running in a loop, using C++, or with a more slimline Tensorflow model), we don't really have any hope of classifying things in real time.

13 CLEVER TWEAKS

Furthermore, it's likely that a photo taken at ground level with the Pi Cam will be tricky for the script to identify. But that's OK, it just adds to the fun. All we need to do is tweak classify_image.py a little. Copy this file to classify_photo.py, then edit the new file. You need to import the "picamera" module early on, then in the `main(_)` function, replace the line that begins with `image =` with something like:






```
cam = picamera.PiCamera()
cam.capture('/tmp/picam.jpg')
```

» And finally, change the `run_inference_on_image()` call to run on our freshly captured picam.jpg. If you're feeling adventurous, why not bind the new script to some button press event? The controller script for the DiddyBorg, which we discussed earlier, could easily be adapted to do this.

14 FOLLOW THE BALL

OpenCV is a powerful computer vision framework that includes Python bindings. It's actually used to draw the image in the earlier web UI example, but we can use it for more advanced purposes, too. It's capable of detecting objects within an image, which means we can make our robot drive toward them. If those objects move, then our robot will follow them. For this to work, said objects need to be fairly distinct, such as a brightly colored ball [Image J]. You'll find just such an example at www.piborg.org/blog/diddyborg-v2-examples-ball-following.

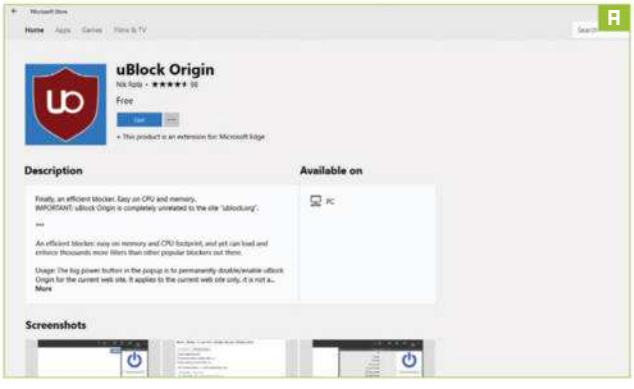
Stop Every Online Ad in its Tracks

YOU'LL NEED THIS

UBLOCK ORIGIN
Available from the Microsoft Store.

IS YOUR PC CRUMBLING under the weight of flashy banner ads, irritating pop-ups, and cheesy jingles from websites hell-bent on hawking their wares? Then help is at hand in the form of ad-blocking extensions, such as uBlock Origin. These work inside your web browser to prevent advertising content from loading, allowing you to use your favorite web services in peace. While uBlock Origin has been around since 2014, it's only recently become available for Microsoft Edge via the Microsoft Store, thanks to the efforts of creator Raymond Hill and developer Nick Rolls.

Unlike other popular extensions, such as AdBlock Plus, which allow some "acceptable" content through, uBlock Origin blocks all advertising by default. Combine this with an extremely low memory footprint relative to other ad-blockers, plus a very intuitive user interface, and you may wonder how you ever survived without it. Before starting, we would like to caution that less is more when it comes to ad-blockers, and indeed all privacy extensions. If you already have an ad-blocking extension installed, be sure to remove it before installing uBlock Origin, otherwise it can cause conflicts. Some websites may not display correctly when filtered for ads; fortunately, uBlock Origin enables you to fine-tune and even whitelist certain webpages. **–NATE DRAKE**



1 INSTALL UBLOCK ORIGIN

Before starting, save and close any currently open files. If you have not already done so, be sure to run a backup of your system. We also recommend running Windows Update to make sure you have the most recent version of Microsoft Edge. You can access this under "Settings" on Windows 10.

›› When you are done, open the Microsoft Store and type "uBlock Origin" into the search bar at the top-right. Once uBlock Origin appears in the Store window, click it to be taken to the application page. Click the "Get" button to begin installation [**Image A**]. Once the download is complete, click "Launch" to open Microsoft Edge. The browser now asks you to confirm that you want to install the extension, and lists permissions. Click "Turn it on" to continue. uBlock Origin icon now appears on the top right-hand corner of your Microsoft Edge window.

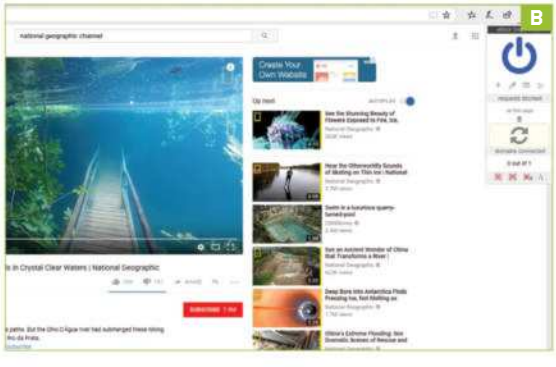
2 BASIC FEATURES

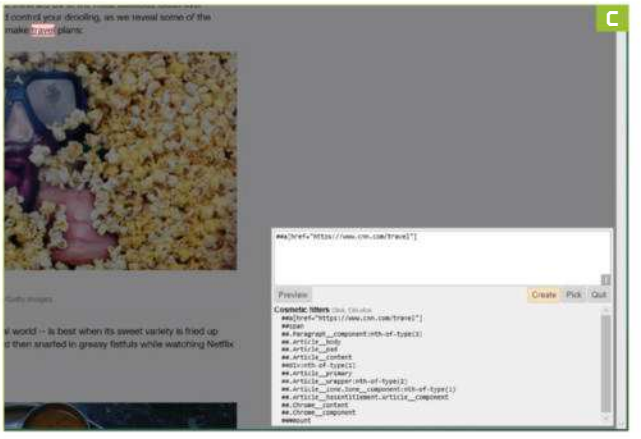
As you browse websites in Microsoft Edge, you may see numbers over the uBlock Origin icon on the top-right. This reflects the number of advertisers that are being blocked on the current website. Click once on the uBlock Origin icon to view the number of "requests blocked" both on this website and other websites you have visited since you installed uBlock Origin. The "Domains Connected" value lists the number of distinct websites to which Microsoft Edge is currently connected. The uBlock Origin Extension tries to filter out harmful ones by comparing them to a regularly updated public list of potentially harmful domains. While ad-blocking can be helpful, it may interfere with the functionality of some websites. To quickly disable the uBlock Origin extension for the site you are currently visiting, click the blue power button. Remember, this disables all ad-blocking features for this domain. If you still want to filter out content, you can use the element picker/zapper (see below).

3 FINE-TUNING

By default, uBlock Origin doesn't block all pop-up windows, because they may contain information you need. If, however, you are being plagued by pop-ups, click the pop-up icon in the uBlock Origin window, which resembles two small sheets of paper. An "x" appears over the button if pop-ups are being blocked [**Image B**]. The adjacent button, which resembles a movie reel, is useful for blocking large media content, such as high-quality images and videos, which take a long time to load. The eye symbol button toggles the display of cosmetic elements. You should only need to click this if certain webpages aren't displaying properly. If you choose to show cosmetic elements, some ads may leak through also.

›› Certain websites use their own fonts for text instead of those on your computer. This takes up more bandwidth and





can potentially be used to run harmful code. To disable "remote" fonts, click the fourth button, which resembles the letter "A."

4 MASTERING THE ELEMENTS

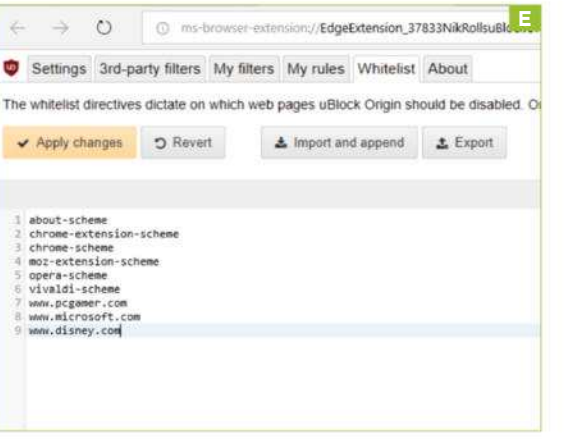
Although uBlock Origin does its best to strip out advertising-related content, you may still see annoying things, such as banner ads and photos. Click the "element zapper" (the lightning bolt button) to choose which elements of your current webpage to show and hide. These changes are temporary, and usually revert next time you restart Microsoft Edge. If you make a mistake and block the wrong element, just refresh the page to undo any changes made with the zapper.

›› If there is an element on a webpage you wish to remove permanently, click the small "eye-dropper" icon next to the element zapper button. This launches the "element picker." Hover your mouse over the element you wish to block. It is highlighted in red [**Image C**]. Click to launch the pop-up window, then choose "create" to enforce a new filter for this element from now on. You can view a list of any filters you have set up using the uBlock Origin dashboard, as well as edit and remove them.

5 DASHBOARD SETTINGS

Click the fourth button to open the uBlock Origin dashboard [**Image D**]. From here, you can access the main settings. If you want to display placeholders of blocked elements, uncheck "Hide placeholders of blocked elements."

›› If you don't need to see the number of blocked requests for every website on uBlock Origin, uncheck "Show the number of blocked requests on the icon." Click "Disable Tooltips" if you feel comfortable with using uBlock Origin. Visually impaired users may find reading easier by enabling the "Color-blind friendly" feature. The uBlock Origin extension supports using cloud storage services, such as Dropbox, to sync your ad-blocking settings across your devices. Click "Enable cloud storage support" to allow this



feature. A new tab appears where you can enter your log-in details. If you only use Windows devices, you shouldn't need to do this, because provided you are signed in with your Microsoft Account on every machine, your uBlock Origin settings sync automatically.

6 MANAGING LISTS

By default, uBlock Origin incorporates a number of public lists, which detail spammy sites, annoying ads, and other objectionable content. These are automatically updated, so you should not need to change any of the settings under "3rd Party Filters" in the dashboard. One exception may be if you find pages are loading exceptionally slowly. Click the "Purge all caches" button to refresh the information.

›› If you regularly access foreign language content, scroll down to "Regions, languages," and click your language(s) of choice. Click the "Apply Settings" button to download the relevant ad-blocking list(s) for your region.

›› If you have whitelisted any sites by clicking the blue on/off button under the uBlock Origin icon, these appear in the whitelist tab in the dashboard [**Image E**]. Remember that this disables all uBlock Origin features on that website and any sub-domains. If you've accidentally added a site to the whitelist, left-click to select, then right-click, and choose "Cut." Click "Apply Changes" to confirm the removal.

BOOSTING PRIVACY

Sharp-eyed users may notice that uBlock Origin's dashboard has a small privacy section, which attempts to prevent your IP address from being leaked via Content Security Violation reports. Ad-blocking in itself won't prevent websites from tracking your browsing habits. Often, this is done via installing "cookies" on your machine, which allow sites to build a profile about you. This is usually quiet harmless, but if you need a life insurance quote, for instance, you may be uncomfortable with the insurance company knowing that you ordered a book on how to stop smoking a few days ago.

Consider installing the Ghostery extension via the Microsoft Store to block most of these tracking cookies. These extensions won't stop anyone with access to your ISP's records from knowing which website you have accessed, though, so if you really value your privacy, sign up with a reputable VPN (virtual private network) provider, such as Golden Frog (www.goldenfrog.com). This will mask your IP address from websites you visit.

Get the Most from MS Sticky Notes

YOU'LL NEED THIS

WINDOWS 10
Version 15063.0 or higher.

INTERNET CONNECTION
Needed for certain features, such as live stock prices.

VOIP SOFTWARE
Required to place phone calls.

MICROSOFT STICKY NOTES has grown from its humble origins as a Windows Vista gadget to a rich and fully featured app. Available free with the latest version of Windows 10, it enables you to easily jot down to-dos, reminders, contact details, and other vital tidbits of information. One of the best features of version 2.1 is its integration with Cortana. You can now enter a date or time, and Cortana automatically creates a reminder for you. If your notes include a street address, you can click on it to view the exact location in Maps. All web addresses typed into a Sticky automatically convert into hyperlinks, too.

If you've written down any phone numbers, just click these inside any note to automatically make a call via Skype or similar. If you are dabbling in investments, Sticky Notes can also provide you with the latest stock prices. Users of Surface Pens will find that Sticky Notes faithfully preserve your scrawlings in your own handwriting. Windows 7/8 veterans who have used previous iterations of this app may find that their notes don't automatically copy across to the new version. Luckily, there is an easy way to fix this (see below). **–NATE DRAKE**

1 LAUNCH STICKY NOTES

If your system is up to date, it should already include the latest version of Sticky Notes (2.x). Double-check this by closing and saving any open files, then clicking the Windows icon, followed by the "settings" icon, and going to the "Update and Security" section. Select the option to update. You may need to restart your system. Once the system update is complete, launch Sticky Notes by clicking the Windows button, and scrolling to Microsoft Sticky Notes [**Image A**]. Alternatively, if you are in the Microsoft Store, you can launch from here by searching for "Microsoft Sticky Notes," then clicking the "Launch" button. Sticky Notes automatically saves notes you create, so they can be restored each time you restart your machine. If anything happens to your hard drive, however, the notes may be lost. Make sure you run regular system backups to prevent this from happening.

2 YOUR FIRST STICKY NOTE

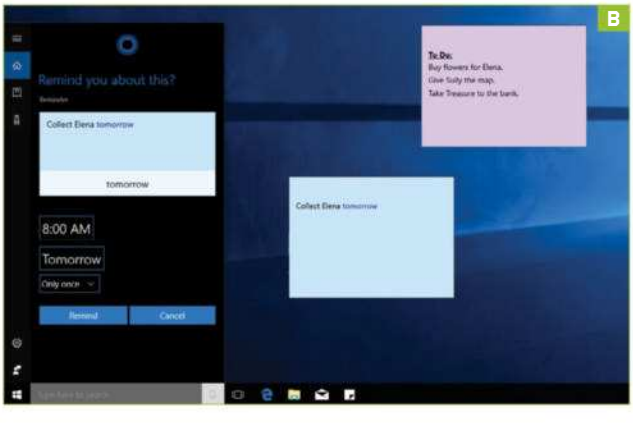
Once the program launches, a blank yellow sticky note appears in the center of the screen. Click the note to enter text. You can format text using keyboard shortcuts—Ctrl-B for bold, for example—if you wish. To resize notes, hover your mouse over any corner, and then click and drag. To move them, simply hover your mouse over the top of a note, and move it anywhere you like. To change note color, click the "options" button (three dots) at the top-right corner of any note. Microsoft has generously offered a palette of lemon, grass, rose, amethyst, sky blue, and clean.

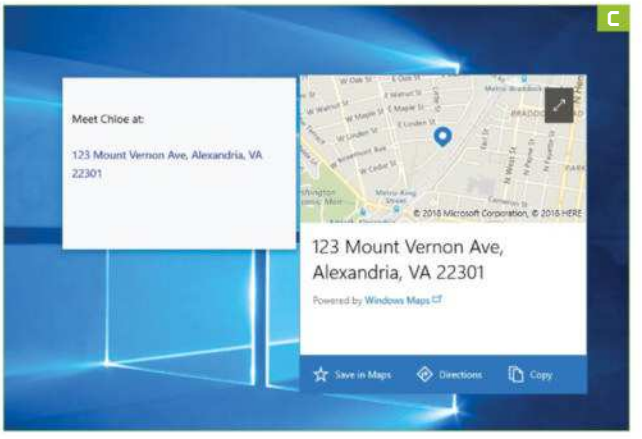
» To create a new note with the same properties as the current one, press the "+" button on the top-left, or use keyboard shortcut Ctrl-N. You can copy and paste from outside sources, such as a webpage or Wordpad document, but any formatting, such as fonts or text alignments, are lost. Insert an asterisk and a space for bullet points.

3 CORTANA REMINDERS

Sticky Notes can interface with Cortana to create a reminder when you write down a task you need to do on a particular date or time. Currently, this feature is only supported if your region is set to the United States in "Settings" in the "Time and Language" section. To get started, click the options button on the top-right of any note, and choose "Settings." Next, turn on "Enable insights," and press the "x" on the top-right to close. If Cortana is not already running, hold down Windows-C to wake her up. Make sure you are signed in to Cortana with your Microsoft Account before continuing.

» From now on, whenever you enter a date and time, it appears highlighted in blue. If you then click on the highlighted word, the option to add a reminder appears. Click on this, and Cortana opens, displaying your sticky note. The reminder is now created, but you can edit the date and time if you wish [**Image B**].





4 ADDING ADDRESSES

Sticky Notes is smart, in that it automatically detects addresses you add. If you enter a location, such as a street address, when creating a sticky note, it is automatically highlighted in blue. Click this and select "View Address" to see the location in the Maps app [**Image C**]. Please note, for this to work properly, you must enable location services and maps in "Settings," then "Privacy Location Services."

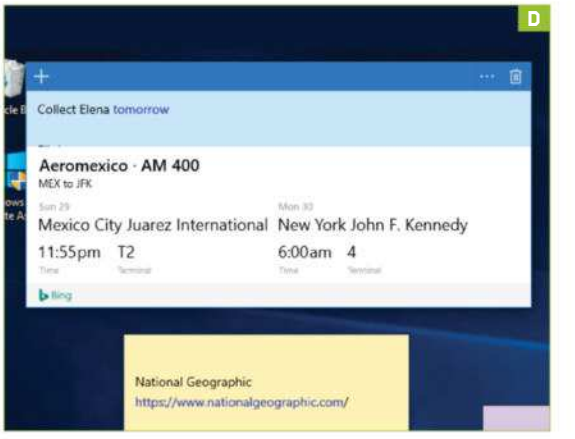
›› If you have a slow Internet connection, it may take some time to load the correct location. Consider downloading an offline map for your particular region to speed up the process. Follow the steps at https://bit.ly/2vYIYM0 to do this.

›› Websites work in a similar way. Simply type an address into a note—www.nationalgeographic.com, for example—and the text automatically converts into a hyperlink. Click on any web address in Sticky Notes, then choose "Open Link" to launch the site in your default browser.

5 ADDING FLIGHT AND CONTACT NUMBERS

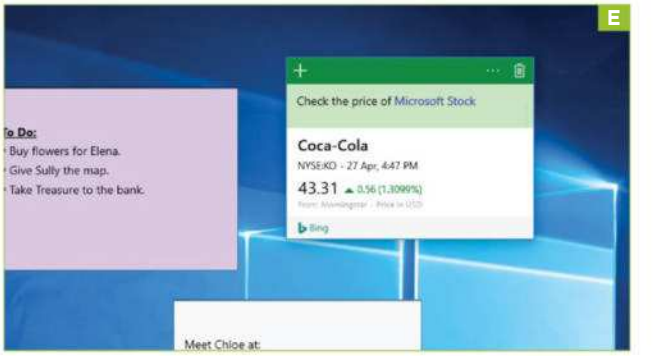
If you have a flight to catch or need to pick someone up, just enter the flight number into any note. The flight number is highlighted in blue. Click this to view detailed flight information, courtesy of Bing. This includes flight departure and arrival times, as well as the departure and arrival cities [**Image D**].

›› If you have a compatible app, such as Skype, you can use Sticky Notes to make calls automatically. To get started, enter a phone number in the international dialing format. For example: A. Smith +15431234567. The number now appears in blue. Click this, then select "Call" to launch your chosen voice app. The first time you do this, Sticky Notes asks you to choose the app that you want to perform the task. If using Skype, make sure you are signed in with your User ID/ Microsoft Account before proceeding.



6 STICKY STOCK TICKER

If you trade on the US Stock Market, Sticky Notes can use Bing to provide you with real-time trading prices. The app enables you to do this in a number of ways. For instance, you can make price information appear by typing a "$" before the ticker symbol for a company—for example, "$MSFT." Or, if you reference "x" stock, where "x" is the name of a publicly traded company in the US, pricing info also appears. You can write either the ticker symbol or the name of the company—for example, "Microsoft Stock" [**Image E**]. If not in the US, you need to set your region to the United States in "Time and Language" settings for this feature to work. Microsoft hopes to support more countries and exchanges in the future. If you hold shares outside the US, you can still insert a hyperlink into Sticky Notes—for example, https://finance.yahoo.com/quote/FUTR.L?p=FUTR.L. You can click this to view the latest share prices online in your stock exchange of choice.



MIGRATING AND BACKING UP STICKY NOTES

Users of the previous version of Sticky Notes on Windows 7/8 may want to import their note to the latest iteration. Sticky Notes now uses an ultra-efficient SQLite database, which is incompatible with the .snt format used by previous versions of the app. If you do want to move your notes across, copy the .snt file located in "C:\Users\login\AppData\Roaming\Microsoft\Sticky Notes" on your older Windows machine to a safe location, such a USB drive. Then rename the copied file to "ThresholdNotes.snt." Next, move to your Windows 10 machine, and close down the Sticky Notes app if it is running.

Open the Windows menu and go to "Settings → Apps → Sticky Notes → Advanced Options." Click "Reset." Bear in mind this will delete any existing sticky notes on your Windows 10 machine.

Next, open File Explorer, click "Quick Access," and type "%LocalAppData%\Packages\Microsoft.MicrosoftStickyNotes_8wekyb3d8bbwe\LocalState." Open the folder named "Legacy." If this folder does not exist, right-click inside the File Explorer window, and choose "New → Folder" to create it. Paste the .snt file you coped from your old Windows machine earlier into the "Legacy" folder. When you next launch the Windows 10 Sticky Notes app, the old .snt file will be converted to .sqlite format.

Create Kaleidoscopic Patterns from Photos

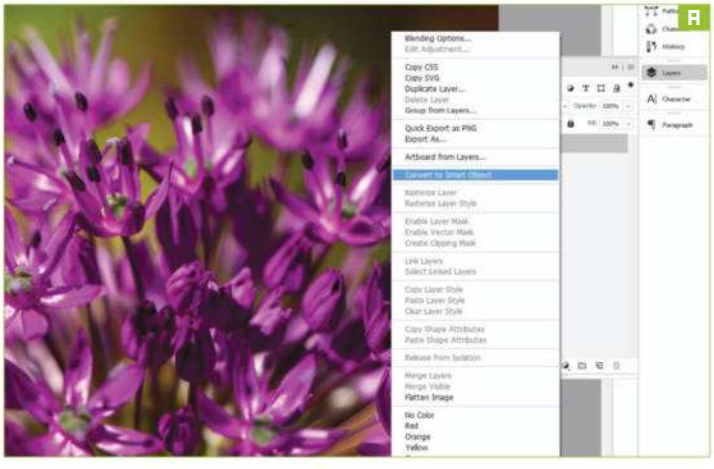
YOU'LL NEED THIS

ADOBE PHOTOSHOP
Sign up for a subscription plan at www.adobe.com.

ART, SO IT'S SAID, IS ITS OWN REWARD. The artifact you create has a beauty of its own that extends over and beyond that of its constituent parts. So, even if you're not going to display your work, there's value to be had from the simple act of creation.

Photoshop's ability to layer images on top of one another gets another dimension when you add in the capacity to rotate one of the layers, shrink it in size, or generally warp it. Photoshop's Smart Objects feature links a layer to a source file, meaning that however much you distort it, no data is lost—the original file isn't altered, and the original data can be constantly referenced.

Here, we're going to use it to make kaleidoscopic patterns from a single photo, but Smart Objects can come in handy whenever you're importing data from one image file into another. **–IAN EVENDEN**



1 CREATE A SMART OBJECT

When choosing an image for this treatment, we find something with strong colors and distinct areas of color works best. Get your image open in Photoshop (any version from CS3 should work, although we're using the latest CC), and double-click the Background layer. Give it a name, or leave it as Layer 0, and hit "OK." Right-click the newly named layer, and choose "Convert to Smart Object" from the menu that appears [**Image A**]. The layer thumbnail should change slightly to let you know it's been converted.

2 ADD FILTERS

Next we need to increase the contrast of the image, and break it up into lines. To do this, we're going to completely ruin the photo with the Mezzotint filter. Find it under "Filter → Pixelate," and choose either of the "long" options from its "Type" drop-down menu. You'll get an unusual result, but we can begin to see the makings of something worthwhile by applying the Radial Blur filter, too ("Filter → Blur → Radial Blur") [**Image B**]. Because we're working with a Smart Object, Photoshop applies its filters as Smart Filters—non-destructive effects that appear in the Layers panel as a list below the Smart Object. Smart Filters can be turned on and off, or edited long after they've been applied, but can be a bit taxing on your system. We certainly heard the fans on our i7's water-cooling radiators spin up as we did it. In the Radial Blur options window, set "Amount" to "100," "Blur Method" to "Zoom," and "Quality" to "Best." We ended up with something that looks like a sci-fi warp speed effect, but your mileage may vary.

3 KEEP ON FILTERING...

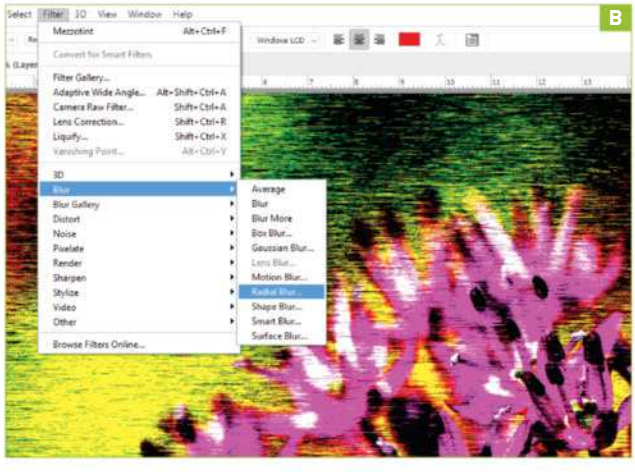
Next, we keep adding new Radial Blur Smart Filters, using the same settings. Photoshop places your last-used filter at the top of the Filter menu, so you don't need to go digging in sub-menus. Hit the filter two more times, for a total of three. You should now have a very smooth effect, like god-rays descending into a colored ocean. Or something like that. Now apply another filter—Twirl—which is found under "Filter → Distort" [**Image C**].

4 GIVE IT A TWIRL

Twirl's options box contains an Angle slider that controls the level of twirling. Sliding it to the left twirls counterclockwise, and to the right twirls clockwise. We went for a big clockwise twirl of 510°, which gives a tightly twirled center. Again, this is added to the Layers palette as a Smart Filter, so can be edited later if you right-click its entry and choose "Edit Smart Filter" [**Image D**]. Try this now with the Mezzotint filter, and see how the effect changes if you change its Type. Doing this re-applies every filter on top of the one you're editing, as well as the edited one itself, so it can spin up those fans again.

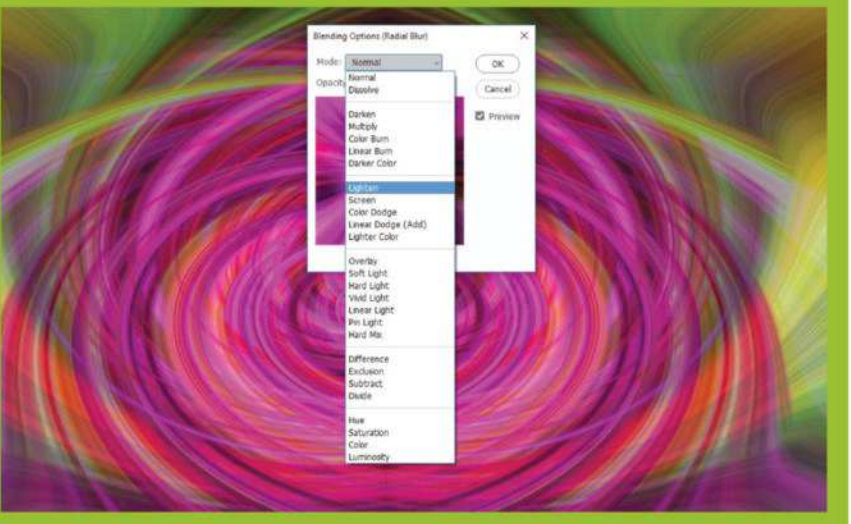
5 BLEND IT UP

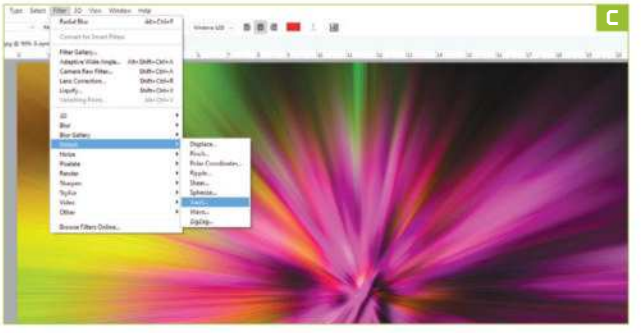
Duplicate your Smart Object layer by right-clicking it and choosing "Duplicate Layer" (this freshly applies the Smart Filters to the new layer, so there will



SMART FILTERS

The Shadows/Highlights adjustment, found under "Image → Adjustments," is also applied to Smart Objects as a Smart Filter. Being able to go back to this adjustment and change its settings after you've worked on your composition for a while is incredibly useful. Further benefits of Smart Filters are the ability to reorder them in just the same drag-and-drop way you would the Layers palette, and blend them into one another directly by double-clicking one, waiting for some rendering to happen, and choosing a Blend Mode from the window that pops up. Smart Filters are applied from the bottom up, so blend in exactly the same way as layers.

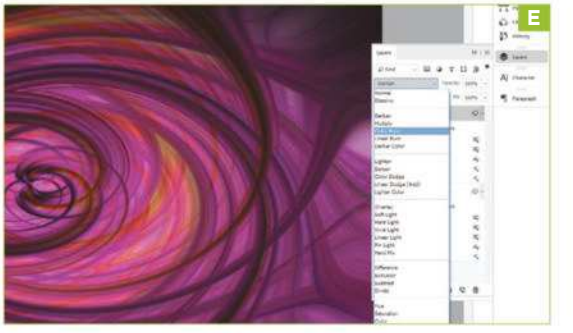



C

be some processing time), and edit the Twirl Smart Filter on the new layer, so it twirls in the opposite direction by the same amount. The new layer completely covers the original one below, so to let it show through, we're going to do some blending. Switch the Blend Mode of the upper layer to "Darken" using the drop-down on the Layers palette [**Image E**], leaving the opacity at 100%, and you'll see patterns begin to emerge. Experiment with different Blend Modes to see which gives the strongest or most pleasing effect. We had good luck with Pin Light and Exclusion.

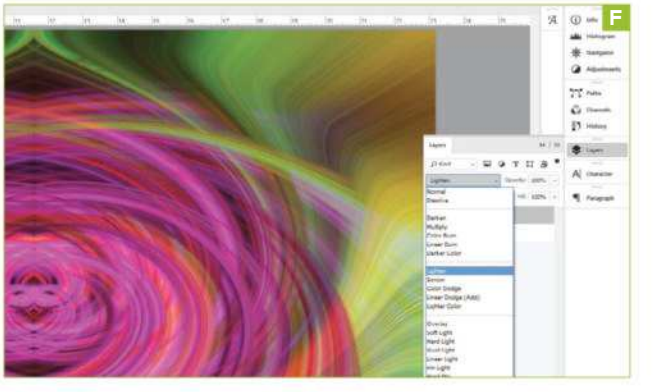
6 ADD SOME SYMMETRY

To make a symmetrical pattern, first merge your Smart Objects by right-clicking one of them and choosing "Merge Visible." You need to be happy with the way they look at this point, as the merge process converts them to a normal layer—so don't


E

do this until you've finished tinkering. If you want to create a new layer without affecting the Smart Objects, you can use the keyboard shortcut Shift-Ctrl-Alt-E, which pops the new layer on the top of the stack, but it's not mirrored in the menu commands, so we can't say for sure if it's supported in versions of Photoshop older than CC 2018. If you do it this way, you still need to flatten the layers ("Layer → Flatten Image") before exporting. Duplicate the new layer just like you did in Step 5, and flip the top one horizontally with "Edit → Transform → Flip Horizontal." Then it's just a case of changing the Blend Mode to something like Lighten or Darken [**Image F**]—whichever looks best in your eyes—and you've got a symmetrical, kaleidoscope-like pattern generated from a single image file. Export it as a JPEG or PNG for sharing or to use in another project.

D


F

BUILD IT

ALAN DEXTER, EXECUTIVE EDITOR

Super Storage Show-Stopper

AMD's StoreMI offers up some enticing options for budget builders—let's see how it performs

LENGTH OF TIME: **1-2 HOURS**

LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

THE IDEA BEHIND THIS BUILD is a slight departure from the norm: We wanted to find out what AMD StoreMI was capable of. However, we also wanted to extend the ethos behind the tech to the rest of the system. StoreMI, in case you missed it, pairs a spinning hard drive with an SSD to potentially offer the best of both worlds—high-speed access with large capacities. Something that would set you back a good chunk of cash if you were to simply buy a capacious SSD.

So, the general ethos is great value for money, but it's more than simply focusing on the budget end of the spectrum—it's the best balance between value and performance out there. To this end, we've set out to build a machine that offers the best value for money right now. It isn't just that, though, because great value for money can cover a range of price points. There is something special about machines that cost around $1,000, and that's the price we've had in mind when building this rig.

So, we have a tech we want to explore and a general price point, but what of the machine's purpose? Given the price point, it should be a mid-range machine that is capable of a wide range of tasks. The kind of general-purpose machine that is built every day, if you will. This also gives us chance to see how StoreMI works in a range of applications and situations, as well as a smattering of games.

As is always the case with these builds, you don't have to follow this build to the letter, and this is especially true here as we're trying to see how StoreMI performs; even so, the final build should stand on its own regardless. That said, let's look at the components we've decided to use....

THE SEARCH FOR VALUE

IT'S ACTUALLY QUITE TRICKY in the current market to make a call on the best value gear, simply because a lot of our go-to components have seen their prices explode, meaning they're not as attractive as they once were. Graphics cards, in particular, have had a rocky ride recently, and while we once would have reached for a GeForce GTX 1070 for a mid-range rig such as this, these days we have to set our sights a little lower, unless we want to bump into the $1,500 price bracket instead. This is why we've reached for a GeForce GTX 1060 6GB, although if gaming is of no interest, you can pick up a GTX 1050 instead for around $150.

For the heart of the system, we've elected to give the Ryzen 5 2600 a spin, and have paired it with one of the more affordable X470 motherboards around in the shape of the Gigabyte X470 Aorus Ultra Gaming. There are combo deals to be had with these two, so it's worth taking a look at your retailer of choice when buying—at the time of writing, Newegg has both of these together to save $20.

In order to test StoreMI, we've grabbed the recently released Samsung 970 Evo 250GB M.2 and paired it with a 1TB WD Caviar Blue hard drive. Amazingly, the new 970 Evo actually retails slightly cheaper than the older 960 Evos, so that's one of the easiest upgrades we've ever made. This build also showcases Cooler Master's newest case, the MasterBox MB500, which we're eager to build in. Finishing off the spec list, we've got 16GB of DDR4-2400 G.Skill RAM, and an affordable power supply from Cooler Master as well. Now that's all done, let's get building.

INGREDIENTS

PART		STREET PRICE
CPU	AMD Ryzen 5 2600	$200
Motherboard	Gigabyte X470 Aorus Ultra Gaming	$140
GPU	Nvidia GeForce GTX 1060 6GB	$300
Memory	G.Skill Flare X Series 16GB (2x 8GB) DDR4-3200	$240
Storage 1	Samsung 970 Evo 250GB M.2-2280	$110
Storage 2	Western Digital Caviar Blue 1TB 3.5-inch 7,200rpm	$44
Case	Cooler Master MasterBox MB500	$69
PSU	Cooler Master MasterWatt Lite 500W	$40
OS	Windows 10 Home	$100
Total		$1,243

1 SWITCH COOLING

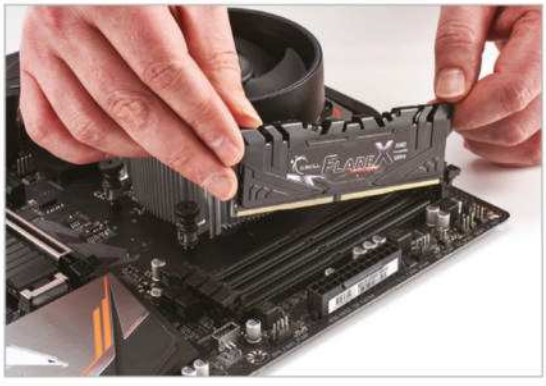
THE GIGABYTE X470 AORUS Ultra Gaming, like most AM4 motherboards, ships with support for clip-on coolers, but if you're using the Wraith Stealth cooler, as we are here, you need to unscrew the default brackets first. Once out of the way, you have to hold the backing plate in place, and then screw the Wraith Stealth into position. The best way of doing this is to work in diagonals—partially screw one corner into place, move to the opposite corner and partially tighten that one, then work on the other two corners. Once they're all in situ, you can finish off by tightening all four screws. Don't forget to attach the fan power cable to the motherboard, and you're done.

2 INSTALL THE M.2

SOME ITEMS ARE EASIER to install before you slide the motherboard into place, and one of those is the M.2 SSD. Grab your trusty screwdriver, and release the heatspreader above the top M.2 drive slot. You should then unscrew the post from the bottom M.2 drive slot, and screw it into place, before dropping the Samsung 970 Evo into the slot, and securing it with the post you've moved. You can then peel the film off the heatspreader, and ease this down on top of the drive, before screwing that in place. This drive socket is completely hidden by the graphics card when you install that, so it's worth checking this is sorted before going any further.

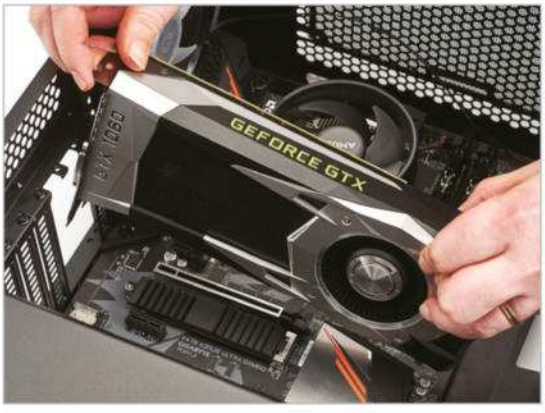
3 CLICK INTO PLACE

WE'VE ELECTED TO INSTALL the memory before slotting the motherboard into place, purely because doing so outside of the box gives us a little more space to work with. Check the motherboard to see which memory slots you should use first, as this should be printed on the motherboard somewhere (and it's rarely obvious). Once done, you should install the motherboard stand-offs into the case, then clip the IO backplate into place. You can now ease the motherboard into the chassis and screw it in place using the case's supplied screws. Keep an eye out for any stray cables that can get trapped under the motherboard if you're not careful—we moved the rear fan's cabling out of the way for this very reason.



4 GRAPHICS TIME

WITH THE MOTHERBOARD IN PLACE, you can now add the other components. When it comes to adding your graphics card, you need to remove the two PCI blanking plates before dropping the card into position. The MasterBox MB500 is a little odd here because there aren't any guides either side of the blanks, but you still can't go wrong. Once the graphics card is installed, hold it in place with the two screws. Next up, we installed the hard drive in the top of the hard drive cage, which can be found in front of the PSU at the bottom of the machine. The brackets for this are toolless, and really easy to use—just make sure you have the drive the right way around.



5 POWER UP

WE'RE SO USED TO MODULAR POWER supplies here, that we're always a little shocked when handling a normally cabled PSU, but it really doesn't make that much difference (other than to your wallet). Release the two thumbscrews holding the PSU bracket in place, then attach this to your PSU, making sure that you've got it the right way so that the fan is pointing down. Thread the cables through the hole, then push the PSU into place, screwing the plate into position once you've made sure you haven't trapped any cables in the process. You can now attach the motherboard, graphics card, and drive power cables, while trying to keep good airflow in mind.

6 LIGHTS, CAMERA, ACTION!

RGB LIGHTING ISN'T SOMETHING we usually get too excited about—in fact, we found the RGB-lit fans of the MasterBox MB500 overpowering—but there is a bit of lighting we do like, and that's the pairing of the motherboard lighting with the Wraith Stealth CPU cooler. Connecting the (incredibly long) cable that comes with the Wraith cooler to the LED CPU header, which can be found next to the top PCIe x1, lights up the ring on the cooler. You can change the color of the motherboard LEDs and the Wraith in the BIOS, or by using Gigabyte's Windows app later on if you wish. After a final check of your cabling, the hardware side of your build is finished.

1 **The Cooler Master MasterBox MB500 ships with three LED fans, but you can run these without lighting up your case by simply not connecting them to your motherboard's LED header—just use the Molex connector on its own.**

2 **AMD's Wraith Stealth cooler is impressive—it runs quietly, while keeping the chip cool (what more could you ask for?). The LED ring is subtle enough to keep us happy, too, and it's an easy way of seeing that everything is powered.**

3 **There's plenty of room in this case for a full-length graphics card, but the GeForce GTX 1060 is such a good card at 1080p, that we didn't feel the need to go any bigger. The fact that pricing has returned to normal helps, of course.**

4 **We could have done a better job with the cabling in this build, but we were so eager to get StoreMI up and running, that we didn't spend the 15 minutes needed to just elevate this build above the norm. Still, there's good airflow in the case, so not much harm done.**

BUILT FOR STORAGE

THERE WEREN'T ANY nasty surprises for us here, and the build process went without a hitch. We were momentarily confused by the lack of a securing post on the main M.2 slot, but realizing we could borrow the one from the unused bottom slot, it didn't hold us back for long. You could argue that you don't need it at all, as the heatspreader holds it securely, but as our machines get couriered from the photo studio back to the office for testing, we prefer to overprovision, as opposed to finding our components rattling around later on.

Getting up and running with StoreMI wasn't as straightforward. After installing Win 10 on the Samsung 970 Evo, and downloading the drivers, we proceeded to completely mess up the install of StoreMI. We clicked the wrong checkbox, and instead of producing a super-fast hard drive, we ended up with a machine that wouldn't boot. Frustration set in as we couldn't then get Windows to see any drives, but after checking out the FAQ at www.enmotus.com/amd, we managed to grab the drivers, and wipe the drives with DiskPart.

On the second attempt, we installed Win 10 to the hard drive, then installed StoreMI so the SSD was used to speed up that installation. This time it worked without a problem, so we could get on with testing the performance of the drive tech and the rest of the machine. The performance garnered from this build was exactly what we expected in terms of the games suite and Cinebench score—this is a decent mainstream machine and no mistake. The fact that the zero-point we use for Build It is a previous-generation Ryzen 5 1600 means that the figures really speak for themselves.

How about StoreMI? It's worth noting that a tiered drive system like this takes a while to kick in, and our performance metrics initially showed read performance more akin to what we'd expect from a spinning hard drive (around 180MB/s for sequential reads), albeit with PCIe NVMe write speeds. A few tests down the line, though, and the same benchmark produced the Samsung 970 Evo's normal read performance—the incredible read figures that you can see in the benchmarks below.

While it would be easy to see this as a problem for StoreMI as a technology, it's not as simple as that, especially when it comes to applications you use a lot. It performs exactly as you need it to where it counts. Essentially, if you use a lot of different apps, but rarely, a dedicated, large NVMe is definitely a better deal, but for a more focused selection of apps and games, StoreMI works well.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,152	1,272 (10%)
CrystalDisk QD32 Sequential Read (MB/s)	3,400	3,478 (2%)
CrystalDisk QD32 Sequential Write (MB/s)	1,720	1,542 (-10%)
Rise of the Tomb Raider (Avg fps)	60	77 (28%)
Total War: Warhammer II (Avg fps)	46	46 (0%)
Tom Clancy's Ghost Recon Wildlands (Avg fps)	39	39(0%)
3DMark: Fire Strike (Index)	11,101	11,337 (2%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an AMD Ryzen 5 1600 @ 3.2GHz, 16GB Crucial Ballistix Sport LT @ 2,666MT/s, an EVGA GeForce GTX 1060 3GB, and a 250GB Samsung 960 Evo M.2 PCIe SSD. All tests performed at 1080p at highest graphical profile.

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AMD Ryzen 7 2700

The tinkerer's choice

AMD'S GREATEST ACHIEVEMENT with its first-gen Ryzen processors came from one tiny little CPU: the 1700. At first glance, amid all the hype and hubbub surrounding the 1800X and, more importantly, the hex-cored 5 series that followed soon after, we'd dismissed the lower-powered 1700 as nothing more than a superficial part, a lineup-filler designed for those on a budget, or power users looking for particularly good energy savings.

The reality was completely different. Shattering all our expectations, our sample, at least when overclocked, easily kept up with—and in some cases surpassed—the 1800X in our tests. All it took was a little elbow grease, some additional voltage, and a bump up in the multiplier, and bam! 4.0GHz was a cakewalk. In short, it was enough to convince this overclocking-obsessed reviewer to invest in one, and although we were fooled once by the inauspicious nature of AMD's sleeper agent, we sure as hell weren't going to be fooled again.

At its heart, the 2700 is quite a curious part. Much like the rest of this second generation of Ryzen, there's no architectural change here, no grand shift in manufacturing process, no new socket, or increased TDP—nothing. All the performance gains are leveraged through intelligently designed smaller transistors, and a rethinking of how Ryzen deals with memory latency. Because of that, AMD reckons you'll net a 10–15 percent performance increase across the board with its new generation of processors compared to the previous gen. That's a bold claim, for sure, but nothing that we haven't seen already with last issue's look at the 2700X.

As far as performance is concerned, the 2700 does exactly what you'd expect across our computational benchmarks in contrast with the last generation—the 2700 managed an increase of around 12 percent across all four of our tests. In fact, it looks a lot more like a Ryzen 7 1800X than anything else right now. In Cinebench R15, it scored 163 points in single core versus the 1800X's 161, and 1,603 in multi versus the 1,640 of the 1800X.

BETTER AND BETTER

So, you get eight cores at 3.5GHz (or 4.1GHz for a single core), it's $15 cheaper than the 1800X, which it almost beats, and on top of that, it comes with a cooler. Can it get any better? Yes it can.

This next bit should come with a little disclaimer, and that's the fact that the 1700 and 2700 series are arguably more susceptible to the silicon lottery than anything we've seen from AMD to date. From our own experience with multiple 1700s, maximum overclocks on these parts can vary by as much as 400MHz, depending on the chip in hand and the motherboard you overclock it on. That said, we managed an additional overclock of 800MHz across all eight cores of our Ryzen 7 2700—that's a final clock of 4.3GHz @ 1.45V. With a 360mm radiator chilling it, we never saw temperatures rise above 68 C. Let's be frank—that's damn impressive. We tried edging it up to 4.35GHz, but decided to back off at 1.5V in fear of damaging the chip. In Cinebench R15, that 4.3GHz netted us an awesome 1,911 points, outclassing even last issue's 4.2GHz score from the 2700X at 1,888 points.

Are there any flaws in this grand overclocker's dream? Sort of. There's the power draw. We saw an increase of 31W from the wall under load versus last gen's 1700, from 110W to 141W. But to be honest, 141W of juice from the wall for an eight-core, 16-thread part—when you can pick up a respectable 750W PSU for less than $75—really does seem like we're splitting hairs. On top of that, temperatures were pretty damn good, too; at stock, we never saw anything above 45 C, and as we only managed 68 C at 1.5V under the triple rad, that's pretty good, too.

AMD really has smashed it out of the park with the Ryzen series, and the 2700 is a fantastic improvement over last gen, too. Whether it's price, performance, or overclocking capability, the 2700 hits the mark for the lot. **–ZAK STOREY**

BENCHMARKS

	AMD Ryzen 7 2700	AMD Ryzen 7 1700
Cinebench R15 Single (Index)	**163**	146
Cinebench R15 Multi (Index)	**1,603**	1,435
Tech ARP's X264 (Avg fps)	**33.8**	30.13
Fry Render (m:s)	**02:25**	02:43
AIDA64 Latency (ns)	**68.4**	72.3
AIDA64 Memory Bandwidth (MB/s)	**45,491**	45,481
Power Draw Idle (W)	52	**51**
Power Draw Load (W)	141	**110**
Total War: Warhammer II @ 1080p (Avg fps)	**77**	76
3DMark Fire Strike Dedicated (Index)	**16,001**	15,125
Maximum Overclock (GHz)	**4.3**	4.0
Price to Performance (Cinebench Score/Price)	**5.34**	5.22

Best scores are in bold. Our test bed consists of an MSI X470 Gaming M7 AC, 16GB (2x 8GB) of Corsair Dominator Platinum DDR4, an Nvidia GeForce GTX 1080, and a Samsung 850 Evo 500GB SSD. All games were tested at 1080p on the highest graphical profile.

VERDICT **9** KICK ASS!

AMD Ryzen 7 2700

+ GIGAHERTZ Strong price to performance; impressive overclock headroom; low temperatures; improved latency.

– HERTZ Increased power draw.

$300, www.amd.com

SPECIFICATIONS

Base/Turbo Clock	3.2GHz/3.5GHz
Cores/Threads	8/16
Lithography	12nm
Cache	16MB
Memory Support	64GB DDR4
Memory Channels	2
Max PCIe Lanes	20 (16+4)
TDP	65W

Possibly the best value Ryzen yet.

Zotac Magnus EK71080

Minimalist design, miniature footprint

A FEW YEARS AGO, Valve had this grand plan for Steam Machines—console-like PCs that were intended for gaming on a TV in a living room. Steam Machines never really took off, but we're a big fan of the idea of kicking back on a couch and playing games on the big screen. Of course, we still want those games to be played on PC.

Zotac's Magnus EK71080 fits that bill well. With a squat, black body and minimalist design, it fits right in next to a receiver and cable box—if you still have one of those—on a home theater console. Measuring just shy of 8 x 9 inches, it doesn't take up much space either. The small size is helped by offloading PSU duties to an external power brick, much like the kind used by high-power gaming laptops.

Despite the small form factor, the Magnus still packs a decent punch. It's rocking an Intel Core i7-7700HQ CPU, while gaming duties are handled by an Nvidia GeForce GTX 1080. You'll notice that the CPU, in addition to being a seventh-gen Kaby Lake processor (Zotac announced a Coffee Lake version at CES earlier this year, but we haven't seen it in the wild yet), also bears the "HQ" designation—it's the CPU usually found in laptops, and overclocking is off the table.

The other bummer is that the Magnus is usually sold as a barebones system. It's plenty easy to pop open and upgrade, but the base $1,500 configuration doesn't include RAM, an HDD, or Windows. It does have a 120GB SSD in there, but that's basically just enough for your operating system and maybe a game. The upgraded version costs $1,799 for the addition of 8GB RAM, Windows 10, and a 1TB HDD. That's what we tested, just minus the HDD—as such, we actually weren't able to benchmark *Ghost Recon: Wildlands,* because the game's 95GB install was too large to fit on the measly SSD.

Speaking of games, the Magnus performs OK for its size, but you definitely feel the effects of the mobile processor and single-channel 8GB of RAM. It scored an average of 88fps across *Rise of the Tomb Raider's* three-part benchmark, and 69fps in *Total War: Warhammer II.* Those scores put it—at least with this stripped-down spec—at a bit less powerful than a GTX 1070-powered laptop. That's not very promising, considering the Magnus has a higher-tier GTX 1080 inside, but we have to imagine the lack of RAM is really holding those scores down. We expect a simple upgrade on that front would unthrottle the GPU considerably.

As is, the Magnus is a bit disappointing. We love the small, minimalist form factor, and the concept of using such a box as a living room PC, but it'll need some upgrades to get there. Luckily, the expensive stuff—CPU, GPU, mobo—is all in place, so an upgrade to the RAM and storage shouldn't set you back too much. **–BO MOORE**

VERDICT **6**

Zotac Magnus EK71080

MAGNIFICENT Small form factor; whisper quiet.

MALEFICENT Mobile-level CPU; needs upgrades to perform.

$1,799, www.zotac.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	743	739 (-1%)
CrystalDiskMark QD32 Sequential Read (MB/s)	563	484 (-14%)
CrystalDiskMark QD32 Sequential Write (MB/s)	133	447 (236%)
PCMark 10 Express (Index)	3,852	4,306 (12%)
3DMark: Fire Strike (Index)	13,202	14,830 (12%)
Rise of the Tomb Raider (fps)	99	88 (-11%)
Total War: Warhammer 11 (fps)	62	69 (11%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our laptop zero-point is the Asus GL502VS-DS71, with an Intel Core i7-7700 HQ, an 8GB GTX 1070, and 16GB of DDR4-2400. All game tests are performed at 1080p at the highest graphical profile.

SPECIFICATIONS

Processor	Intel Core i7-7700HQ @ 2.8GHz
Graphics	Zotac GeForce GTX 1080 Mini
Memory	8GB (2x 4GB) DDR4
Motherboard	Custom Zotac
Primary Storage	120GB M.2 SATA SSD
Secondary Storage	1TB 2.5-inch SATA HDD
Cooling Solution	Air cooled
PSU	External 330W Power Adapter
Dimensions	8.9 x 8.0 x 5.0 inches
Warranty	Two years

The Magnus EK71080's small design works well as a home theater console.

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AMD Ryzen 5 2600X

The second coming of six-core Ryzen

FAMILIAR WITH THE broad outline of AMD's second-generation Ryzen processors in the form of the eight-core Ryzen 7 2700X? Then allow us to flesh out the details with this new, more affordable, six-core variant.

Unlike the 2700X, which occupies a slightly different position in AMD's CPU hierarchy to its 1800X predecessor, the Ryzen 5 2600X lines up precisely adjacent to the old Ryzen 5 1600X. In short, it's the premium six-core model. But, just like the 2700X, it's based on what AMD and its production partner Global Foundries are styling as a new 12nm production process.

In theory, the new process offers a range of improvements over 14nm, including 10 percent performance improvement, and 15 percent transistor density. But AMD has not gifted the new chip with the density improvement part of the 12nm process. It has the same die size and transistor count as the first Ryzens. That also reflects the fact that, save for a few tweaks to cache hierarchy, AMD's Zen CPU architecture has been carried over untouched.

That means you get the same 16MB of L3 cache, the same 20 lanes of PCIe 3.0 connectivity directly into the chip, the same six cores with support for two threads per core, and the same dual-channel DDR4 memory controller. What have changed as a consequence of the revised production process, however, are the 2600X's clock speeds. At least, the top turbo rating has been bumped up from 4GHz to 4.2GHz. The base clock remains at 3.6GHz.

We are not, therefore, looking at a major revolution. For that we'll have to wait for the true second-gen Zen 2 architecture. In the meantime, AMD has promised us a little more performance for a little less money. In practice, that's pretty much how the 2600X stacks up: 10 percent more performance is the overall expectation, and verily the 2600X cranks out precisely that much in Cinebench's multithreaded graphics rendering index, lifting the 1600X's 1,256 points to 1,381. The 2600X is likewise 10 percent quicker running Cinebench in single-thread mode.

Video encoding using the X264 codec shows a similar 10 percent uptick. The 1600X's 27.1fps improves to 30.2. It's the same story in Fry Render. From there, the picture is more complicated. The new chip does reduce memory latency fractionally, but memory bandwidth is unchanged. Likewise, there's no improvement in *Total War: Warhammer II*. Even at 1080p, that benchmark is GPU rather than CPU bound.

More relevant and also indicative of the limitations of the new 12nm process, peak power under full CPU load rises from 155 to 177W—a 14 percent uptick in return for just 10 percent more performance. Overclocking is similarly disappointing. In strict terms, the chip didn't overclock at all, achieving 4.2GHz or the same frequency as the advertised all-core turbo. However, forcing all cores to 4.2GHz is not the same as the potential for all cores to run at 4.2GHz in turbo mode. So, overclocking does release a tiny bit more performance. But with the old 1600X running at its maximum overclock of 4.1GHz, the performance delta actually shrinks to just 5 percent.

The upshot of which is that the 2600X has little to offer anyone who owns a 1600X. Instead, what the 2600X does is make it a bit more appealing to undertake a major upgrade, to switch from Intel to AMD. More appealing, that is, but not a slam dunk. As good as Ryzen is—and it is very good—this second iteration doesn't move the game on. Any reservations we may have had about its outright gaming ability or its meager overclocking headroom remain. Time will tell, but the suspicion remains that the true second-gen Ryzen, the one with Zen 2 rather than Zen+ architecture, will be the CPU that fully delivers on what is a very clever and incredibly promising processor. –JEREMY LAIRD

BENCHMARKS

	AMD Ryzen 5 2600X	AMD Ryzen 5 1600X
Cinebench R15 Single/Multi (Index)	**175/1,381**	161/1,256
Tech ARP's X264 (Avg fps)	**30.2**	27.1
Fry Render (m:s)	**03:09**	03:15
AIDA64 Latency (ns)	**67.1**	71.1
AIDA64 Memory Bandwidth (MB/s)	**45,682**	45,636
Power Draw Idle/Load (W)	**49**/177	**49/155**
Total War: Warhammer II @ 1080p (Avg fps)	**76**	**76**
3DMark: Fire Strike Integrated/Dedicated (Index)	**18,032**	17,235
Maximum Overclock (GHz)	**4.2**	4.1
Price to Performance (Cinebench Score/Price)	**6.57**	6.12

Best scores are in bold. Our test bed consists of an MSI X470 Gaming M7 AC, 16GB (2x 8GB) of Corsair Dominator Platinum DDR4, an Nvidia GeForce GTX 1080, and a Samsung 850 Evo 500GB SSD. All games were tested at 1080p on the highest graphical profile.

VERDICT **9**

AMD Ryzen 5 2600X

GRAND CENTRAL STATION Great all-around performance; slightly lower pricing than before.

SWAMP HUT Barely moves the game on; overclocking headroom is essentially zilch.

$229, www.amd.com

SPECIFICATIONS

Base/Turbo Clock	3.6/4.2GHz
Cores/Threads	6/12
Lithography	12nm
Cache	16MB L3
Memory Support	DDR4
Memory Channels	Dual
Max PCIe Lanes	20 (16+4)
TDP	95W

Gigabyte's latest foray into aesthetically pleasing design has hit the mark.

Gigabyte Z370 Aorus Ultra Gaming 2.0

A second take on the last of a generation

AHH, COFFEE LAKE, what a life you've had. Whether it was a response to Ryzen or not, there's no denying that Intel produced some true gems out of that architecture. The quad-cored Core i3-8100 and the hex-cored Core i5-8400, to name just two, are incredible value propositions that we adored. For anyone looking to build a cost-effective machine, these are prime parts, perfect for a super-nippy office machine or better-geared gaming rig.

Couple that with the well-equipped Z370 chipset, and the generation as a whole is far from being dead in the water. But as we've seen time and time again, the effect your mobo of choice has on performance is often less than 5 percent, if that. When it comes to deciding exactly which mobo you want to pair with your processor kingpin, the decision process inevitably comes down to three factors: What form factor do you want, what connectivity do you need, and which manufacturer do you prefer?

Gigabyte's Z370 Aorus Ultra Gaming 2.0 is a revision of one of its more popular mid-to high-end line-ups, the Ultra Gaming. Packing a clean look, plenty of connectivity, and solid dependable performance with an affordable price tag, it's a product that's well placed to hold on to substantial market share, and is a perfect choice for anyone looking to build a mid-range Core i3 or i5 machine.

Compared to the basic Ultra Gaming, the 2.0 features an M.2 PCIe SSD heatsink as standard, and a new 11-phase power design, which helps reduce coil whine when overclocked or under heavy load. One downside of this shift, however, is that you do lose out on the integrated DVI-I support in the rear I/O. Which is a bit odd, as it's replaced by nothing at all. That said, it's a decent, well-rounded upgrade to the platform, especially if you're looking at utilizing an unlocked K-series part.

Right then, let's talk performance. What are we looking at here? The Gaming 2.0 is a bit of anomaly in our testing suite, especially when it comes to power draw. We've commented in the past about how Asus's mobos typically have optimizations in the BIOS that both boost the V-Core and improve performance in Cinebench R15 and GeekBench. It ultimately leads to higher scores in those benchmarks (around 9 percent). However, on the flip side, the trade-offs usually extend to a CPU temperature increase of about six or seven degrees Celsius and, of course, a far higher power draw. The Ultra Gaming 2.0, on the other hand, scores lower in the benchmarks, thanks to its stock configuration, but you do gain those lower running temps, lower power draw, and an overall quieter rig, even without the grunt of Asus's fan profile tech behind it.

As far as overclocking is concerned, we still couldn't push our Core i7-8700K past 5.2GHz, but it did manage that fairly effortlessly, and the coil whine wasn't overly noticeable. One thing we would love to see, however, is a far better BIOS than Gigabyte currently offers. It does the job, but the overall layout and access to information is limited at best, and it tends to look a little dated compared to that of the competition.

All that said, the Gigabyte Ultra Gaming 2.0 is a finely balanced motherboard, with enough guts and fun to support anyone looking at investing in a well-rounded Coffee Lake system. If you're happy to tinker around with a slight overclock to your chip, you can easily match the performance of the Asus competition without much trouble. In the end, it looks good, performs well, and hits the price nail right on the head. **–ZAK STOREY**

BENCHMARKS

	Gigabyte Z370 Aorus Ultra Gaming 2.0	Asus ROG Strix Z370-G	MSI Z370 Godlike Gaming
X265 Benchmark (fps)	27.58	**30.47**	28.32
Cinebench R15 Multi (Index)	1,415	**1,539**	1,422
Fry Render (Seconds)	140	**133**	142
AIDA64 Memory Latency (ns)	**45.8**	48.4	48.9
Power Draw Idle (Watts)	**43**	65	51
Power Draw Load (Watts)	**172**	204	184
CrystalDisk Sequential Read (MB/s)	**551**	550	549
CrystalDisk Sequential Write (MB/s)	**529**	525	504
Far Cry Primal (Avg fps)	**42**	**42**	**42**
3D Mark: Fire Strike Extreme (Index)	9,731	**9,816**	9,682
Maximum OC Achieved (GHz)	**5.2**	**5.2**	**5.2**

Best scores are in bold. Our test bed consists of an Intel Core i7-8700K, 16GB (2x 8GB) of Corsair Dominator Platinum DDR4 3200, an Nvidia GeForce GTX 1080, and a 500GB Samsung 850 Evo SSD. *Far Cry Primal* tested on Ultra settings at 4K.

VERDICT **9**

Gigabyte Z370 Aorus Ultra Gaming 2.0

+ PERFECTLY BALANCED Solid performance; good temperatures; impressive power draw; good price.

– OFF KILTER BIOS needs work.

$170, www.gigabyte.com

SPECIFICATIONS

Chipset/Socket	Z370/LGA1151
Form Factor	ATX
Memory Support	64GB DDR4 @ 4,000MT/s
M.2/U.2 Support	2x M.2
SATA Support	6x SATA 6Gb/s
Max PCIe Support	3x PCIe 3.0 x16 (x16, x8x8, or x8x4x4)
Rear I/O	5x USB 3.1 Type A, 1x USB 3.1 Type C, 2x USB 2.0, Gigabit Ethernet, 5.1 audio, optical out, PS/2 combi port

AOC's latest Agon monitor costs seriously big money.

AOC Agon AG352UCG6

AOC heads upmarket

PICTURE THE PERFECT gaming monitor. Optimized for speed and response, but also practical for daily computing. Not some mega-money trinket with features you'll never use, but a screen that hits the sweet spot where it matters. You might imagine a 35-inch panel, with a super-wide 21:9 aspect, a gentle curve, high refresh, and some kind of frame synching technology.

You'd probably also split the difference between maximizing pixel density for productivity and putting a cap on pixel count to maintain that crucial frame rate. You would, in short, end up with something that looks a lot like AOC's Agon AG352UCG6. AOC was once known as a purveyor of poverty-spec LCD panels. OK, with Philips as its corporate sibling, it has long has access to big-brand clout , but you wouldn't exactly have called AOC aspirational.

That was then. Now, AOC's Agon sub-brand is taking the fight to the likes of Asus's ROG products and Acer's Predator panels. Consequently, the AG352UCG6 nails it when it comes to on-paper capabilities. At its core is a 35-inch panel packing 3440x1440 pixels, courtesy of a 21:9 aspect ratio. That places it an inch larger than the 34-inch form factor that popularized that particular pixel grid. It's also unusual in leveraging MVA rather than IPS panel tech. MVA tends to be strong on contrast and color saturation, but weaker on viewing angles and response.

The latter is intriguing in the context of this panel's gaming-centric credentials. First up, it supports up to 120Hz refresh. To make the most of that speedy update and guarantee the slickest response possible, AOC has also configured Nvidia's G-Sync tech. Elsewhere, the premium feature set is rounded out by a robust and fully adjustable stand, save for pivot, which is a forgivable omission in a large wide-aspect display. Oh, and the chassis includes rear-firing and programmable mood lighting.

First impressions upon firing up don't disappoint either. This panel has a pleasing overall appearance. In fact, it has the subtle feel of an IPS panel, rather than the in-your-face saturation that often signifies VA tech. That said, black levels and contrast are strong points, which is more in line with the typical VA narrative. On the downside, so are the viewing angles. In images used to reveal off-center color deviation, this panel can't compete with IPS for image stability when viewed at acute angles. Likewise, when it comes to punch and vibrancy, this AOC is nowhere near the latest HDR or quantum dot monitors.

Another minor niggle involves the 120Hz refresh. By default, the screen only supports 100Hz. Enabling 120Hz requires a trip into the OSD menu to switch on so-called "overclocking." This menu is controlled by a single joystick on the bottom of the lower screen bezel, and is very confusing to use. More importantly, it's silly to have to enable overclocking to access what is advertised as a core feature. Presumably, AOC thinks overclocking is cool. Which is fine. But it should be reserved for modes that fall outside the standard specification.

That said, in testing, the 120Hz capability and its G-Sync sidekick work flawlessly. Once you've gone 120Hz-plus, you won't want to go back to 60Hz. Of course, you need a beefy and thus expensive graphics card to make the most of the refresh capability. The panel's 3440x1440 native might not be as demanding as full 4K, but it's still an awful lot of pixels (4,953,600, to be precise) to push 120 times a second. –**JEREMY LAIRD**

VERDICT **8**

AOC Agon AG352UCG6

PALM D'OR Pleasing panel; awesome features; solid build.

RED CARPET REJECT Painful sticker price; not the punchiest picture quality.

$1,039, http://us.aoc.com

SPECIFICATIONS

Panel Size	35-inch, 1800R
Native Resolution	3440x1440
Pixel Density	106.5 dpi
Panel Type	MVA
Maximum Refresh	120Hz
Response	4ms
Contrast	2,500:1
Display Inputs	HDMI 1.4, DP 1.2
Connectivity	2x USB 3.0
VESA Mount	100mm
Warranty	Three years

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Samsung 970 Evo 1TB

Samsung's latest reveals the limitations of NAND memory

GENERATION AFTER GENERATION, Samsung's SSDs are the gold standard in solid-state drives. Fully 18 months from launch, its existing 960 Evo and Pro remain among the best in the business. OK, Intel has shaken things up in terms of response times and random access performance with its Optane drives. And Western Digital's WD Black has presented Samsung with stiffer competition for its Evo drives of late. But Samsung remains the brand to beat. It is nothing short of relentless.

Enter Samsung's latest, the 970 Evo, tested here in 1TB configuration. As an Evo drive, it's the value alternative to the 970 Pro's premium proposition. Everything is relative, of course. The 1TB 970 Evo clocks in at $449, so it's hardly cheap in outright terms. It's also very expensive next to, say, a basic but decent 2.5-inch SATA SSD of similar capacity from a big brand, such as the Crucial MX500. That can be had for less than half the money.

This, however, is an M.2 drive and operates on a completely different level from any SATA SSD. Spec-wise, the 970 Evo gets all of Samsung's latest hardware. The main NAND flash memory is Samsung's 64-layer 256Gb 3D TLC, to which Samsung adds fully 6GB of dedicated SLC write cache. A further 18GB of main memory can be dynamically allocated to SLC mode for caching purposes. The form factor, meanwhile, is the popular 2280 variant of the M.2 standard, and the controller is Samsung's new Phoenix chipset. As is often the case with Samsung's controller technology, few details regarding the inner workings of Phoenix have emerged.

What we can say is that the 970 Evo supports the 1.3 iteration of the SSD-optimized NVMe control protocol, and connects to motherboard chipsets via a quad-lane PCIe 3.0 interface. The upshot involves some predictably impressive claimed capabilities. Peak read speed is rated at 3.4GB/s. As for writes, where the SLC write cache is in full operation, peak speeds of 2.5GB/s are possible with this 1TB model. Exhaust the cache, however, and writes drop to 1.2GB/s.

You could argue that the cache-enabled 2.5GB/s write capability is misleading. But Samsung does at least distinguish between cache-accelerated write speed and the drive's core performance. Whatever, just as impressive on paper is the 970 Evo's 4K performance. QD128 reads are rated at 500,000 IOPS, while QD128 writes aren't far behind at 450,000 IOPS. All told, the drive is good for 600TB of writes, and that's backed by a five-year warranty.

So, how does it perform in the real world? Peak speeds are pretty close to the claims. Sequential reads in ATTO Disk Benchmark hit just under 3.2GB/s, while writes are bang on target at 2.5GB/s. The slightly more realistic CrystalDiskMark pegs the reads back to 2.9GB/s, but writes maintain the 2.5GB/s figure, indicating that the benchmark doesn't fully tap out the 970 Evo's 6GB of SLC cache.

Most impressive of all is the 970 Evo's performance in our 30GB internal file copy test. It tears through the data in just 32 seconds. Less stellar, in context, are the 970 Evo's 4K random access numbers in CrystalDiskMark: 68MB/s for reads and 171MB/s for writes. Not exactly slouchy, but such figures don't represent much, if any, progress over the previous generation.

Indeed, that last sentiment arguably holds for the 970 Evo generally. It's awfully quick for what is ostensibly a mainstream M.2 drive, albeit not a particularly cheap one. But we also sense it's beginning to bump up against its inherent technological limitations, be that a quad-lane PCIe interface or NAND flash memory. It will take a new paradigm, a revolutionary new approach, or a new technology, like Intel's Optane tech, to really move the game on. But in terms of mainstream NAND-based SSD technology, this is about as good as it gets and, indeed, probably also as good as it's going to get. –JEREMY LAIRD

BENCHMARKS

	Samsung 970 Evo 1TB	Samsung 970 Evo 250GB	Samsung 960 Evo 250GB
30GB Internal Copy (Seconds)	**31**	76	89
ATTO Sequential Read (MB/s)	3,122	**3,314**	3,019
ATTO Sequential Write (MB/s)	**2,531**	1,541	1,494
CrystalDiskMark Sequential Read (MB/s)	**2,911**	2,833	1,682
CrystalDiskMark Sequential Write (MB/s)	**2,495**	1,525	1,475
CrystalDiskMark 4K Read (MB/s)	**68**	67	64
CrystalDiskMark 4K Write (MB/s)	171	172	**191**

Best scores are in bold. Our test bench consists of an Intel Core i7-8700K, an Asus Maximus X Hero, an Nvidia GeForce GTX 1080, 16GB of Corsair Dominator Platinum DDR4, and a Samsung 850 Evo 250GB OS SSD.

VERDICT **9**

Samsung 970 Evo 1TB

THOR Very strong all-around performance; particularly speedy with cache acceleration.

LOKI Pricey for a mainstream drive; doesn't move the game on dramatically.

$449, www.samsung.com

SPECIFICATIONS

Capacity	1TB
Interface	PCI Express
Control Protocol	NVMe 1.3
Controller	Samsung Phoenix
NAND Type	64-layer 3D TLC
Sequential Read/ Write	3.4/2.5GB/s
Read/Write IOPS	500K/450K IOPS
Warranty	Five years

1More 1MEJH0006

Or "Triple-Driver Over-Ear Headphones," to put it more pleasantly

AS VETERANS OF THE magazine business, we've done extensive research over the years, and we know your eyes flicked to that score box down there before they made it up to these words. We also figure you're probably tutting over a $250 set of cans picking up that sort of score. That's too low a price for them to be audiophile quality, and too high a price for them to be reasonably affordable, right? Yes. You're absolutely right. Heck, let's list some more of their flaws while we're in the mood: The cable's a touch too short, there's no built-in mic, the meaningless "Hi-Res Audio" logo is on the box as some kind of enticement for the unaware—the list goes on.

But 1More's remarkable headphones deserve every ounce of praise we can pour on them. Even getting them out of the box is an experience; proper packaging making way for an included carrying case, then the cans themselves—heavy, solid, and pretty damn beautiful, with the correct orientation marked on the inside of each earcup in inch-high letters, so you don't have to squint for a tiny icon in order to get your stereo orientation straight. The rear portion of the cups is, judging by its perfectly striated pattern, milled straight out of anodized aluminum, and it's far from the only metal component on display. While there is plastic, it's used as a complement rather than a structural centerpoint. The headband is stainless steel, the earcup pivots are metal, and fold inward with a solid clunk when it's time to stow them; these are headphones that are built to last.

Despite the reasonably heavyweight materials on show, comfort has taken equal priority with aesthetics. Each ear's padding is reasonable—not the miraculous superfoam we've seen on some headsets, but absolutely adequate—and it's covered in silky pseudo-leather. The headband features the same material inside and out; pointlessly, it's padded on the outside edge as well as featuring sectional padding on the inside. The real key is that stainless steel band, which has clearly been engineered with some thought; these are brilliantly adjustable and supremely wearable, not squeezing over time, but providing enough pressure to keep the sound firmly in your head, not leaking out.

And what sound. 1More's marketing trumpets triple drivers in the form of a 40mm graphene dynamic driver, a ceramic tweeter, and a bass reflector. That last one is, technically, a bit of a fudge: Bass reflectors aren't really active drivers, more tuned ports or, in this case, a cunningly constructed membrane placed behind the main driver, and behind the transparent window on the cans' outer shell. But 1More has clearly got the hang of the tuning part of things inside these closed-back enclosures. The sound stage is wide; it's woody, crisp, subtle, and brash in equal measure, leaving everything from top to bottom distinct and definable. There's great separation on offer, and while the output isn't completely flat (getting a little pushy toward the bass end, and often very bright on the treble), it's very pleasant. Transformative, even—it could change the way you listen to music. Games aren't the 1MEJH0006's wheelhouse, given the lack of mic, but that acute frequency distinction makes them a great choice if you need to keep your ears on your environment.

That's our argument for the high score. These are headphones, and they do exactly what good headphones should: They sound phenomenal, and feel great on your head. If cans are a key part of your setup, or you feel they should be, 1More's offering could well be worth your investment. If you see them for less than the $250 MSRP, jump on that deal immediately. Sacrifice food if you have to. Your ears will thank you. **–ALEX COX**

VERDICT 9 KICK ASS!

1More 1MEJH0006

+ GREAT CANS Brilliant sound stage; great engineering; superbly comfortable.

– NOT FANS Punishing on the bank account.

$250, http://usa.1more.com

SPECIFICATIONS

Driver Type	Ceramic/graphene/ bass reflex
Impedance	32 ohm
Frequency Response	20Hz–40kHz
Design Style	Closed back
Connectivity	3.5mm jack
Weight	10.3oz
Cord Length	3.3 feet

Antec Kühler H20 K120

Small, quiet, and affordable, but not for overclockers

THERE'S A LOT GOING for the latest all-in-one from Antec: It looks good, is easy to install, it's affordable, and it runs quietly, but this is balanced by its performance, which is... well, nothing too exciting, to be honest. It'll keep your stock-clocked CPU off the Tj Max, but anyone interested in pushing their processor harder is going to want something a bit bigger. We're getting ahead of ourselves here, though, and it's worth dwelling on what Antec's latest cooler does well, because it's actually a great bit of gear.

The problem with many AIO coolers is they need a lot of room. At least, that's the perception. This can be the case in some older chassis, but every modern case we've looked at recently can accommodate at least a dual-fan radiator, and triple-fan rads aren't completely out of the question, even in smaller cases. Still, there are times when you want a compact AIO to take the edge off your processor, and this is where the Antec Kühler H20 K120 saunters in, with its blue-lit fan (it only lights up under load) and budget price tag.

Antec has shifted the water pump away from the top of the CPU block and instead installed it into the radiator, which means that the CPU block is thinner than what you may be used to (it's well under two inches thick). This has the side effect that there are no unwanted vibrations on the CPU itself, which could, in theory, lead to the block working itself loose or, worse, damaging your CPU or motherboard (although we've never experienced this, or heard of anyone suffering from it).

Installation of the K120 is one of the easiest experiences we've had with an AIO, thanks in the main to its tool-free design. The supplied backplate supports AMD and Intel chips, depending on which way around you install it, and there are bolts that work for all the major sockets, including AM4, LGA 2011, and LGA 1151. Some fairly high-end hardware, in other words.

For the Intel Core i7-6700K we use for testing, the installation was particularly pain-free. Slide the bolts into the backplate, screw the offsets into place, clip the bracket over the CPU block, then use the thumbscrews to hold it in place. The fan screws easily on to the radiator, although you need a screwdriver for this job, and for attaching the radiator to your case. Still, it takes mere minutes to install.

All good, then? In the main, yes. The installation is impressive—no doubt about it—but when it comes to cooling, the K120 is held back by its size. The Core i7-6700K isn't a cool chip, but it was hitting high temperatures at stock speeds (85 C in Prime95), and once we overclocked it to 4.7GHz, we found ourselves knocking on 100 C. That's seriously hot. If you're looking for an AIO cooler for your overclocking exploits, we'd recommend looking at something bigger, such as the NZXT Kraken X62.

The counter to these somewhat toasty temperatures is that the K120 is a quiet cooler. Indeed, the PWM fan tops out at 1,800rpm, and even then is barely more than a whisper at 30dBA. The other point in the positive column is the price: At just $55, this is one of the more affordable AIOs around, making it a great cooler for any budget build where noise is to be avoided, and you're not bothered about overclocking. –ALAN DEXTER

VERDICT **8**

Antec Kühler H20 K120

+ WATERTIGHT Affordable; quiet; svelte design; tool-free installation; compact.

– FLOODING Not the coolest; struggles with overclocking.

$55, www.antec.com

BENCHMARKS

	Antec Kühler H20 K120	NZXT Kraken X62
Idle Temperature (C)	32	**25**
Prime95 @ Stock (C)	85	**55**
Cinebench @ Stock (C)	63	**48**
Far Cry Primal @ Stock (C)	63	**44**
Prime95 @ 4.7GHz (C)	100	**75**
Cinebench @ 4.7GHz (C)	81	**62**
Far Cry Primal @ 4.7GHz (C)	91	**51**

Best scores are in bold. Our test bed consists of an Intel Core i7-6700K, a GTX 1080, 16GB of Crucial Ballistix Elite, and a 500GB Samsung 850 Evo SSD. All tests were performed for five minutes each, with a 10-minute cool-down period.

SPECIFICATIONS

Socket Compatibility	AM4, AM3+, AM2+, FM2+, FM1, LGA 2066, LGA 2011-V3, LGA 2011, LGA 1366, LGA 1156, LGA 1155, LGA 775
Radiator Size	120mm
Radiator Dimensions	6.7 x 4.7 x 1.1 inches
Cold Plate Material	Copper
Fan Airflow	73.31 cfm
Fan Noise	20–30dBA
Warranty	Three years

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Cooler Master MasterBox MB500

What's cooler than being cool? Being cheap, too, obviously

YOU COULDN'T ASK for more than this budget-end case provides for a very reasonable $70. Five years ago, a case with three RGB fans and a tempered glass panel would be considered wildly opulent, and priced accordingly. And now, here we are, in the age of flossing, *Fortnite,* and Facebook scandals, staring a budget case in the face with those very features.

Cooler Master has the kind of pedigree to pull off such a feat, you understand. It's easier to put together a low-end gem when you've been putting in the design graft on higher-end models like the venerable HAF X, and iterating on those solid foundations for years, than it would be to devise a solid chassis from scratch. There's not much HAF X DNA visible in the aesthetics of this MasterBox MB500, but the fundamentals of good airflow, easy access, and solid build quality are definitely present and correct.

For a mid-tower, the clearances are all ample: 6.3 inches for CPU coolers, 15.7 inches for GPUs, and 7 inches for the PSU, which lives in a generous self-contained module at the base, and has plenty of space for tidying cables away. Even using a non-modular power supply with several extraneous cables, it's easy to keep things neat by using the PSU enclosure. We did miss having a hole in the back panel above the motherboard to feed a CPU power cable through, and instead had to make a tight connection across the board face, but this is the only concession to the MB500's smaller size and less feature-rich design we came across during a system build. However, the case got lucky that we don't tend to build using a bunch of drives—there's support for just two 3.5-inch drives or three SSDs, located at the base beyond the PSU enclosure.

Drive bays and cable access cutouts aside, it's pretty plain sailing inside the MB500, with plenty of space to screw components in and make cable connections lower on the motherboard, despite just two holes at the side and one below the board. There's a generous space between the motherboard mounting panel and the removable side panel, which means you don't have to go crazy with the cable ties in order to achieve a neat look and good airflow. Just stuff unwanted cable lengths out of sight at the rear: Job done.

How about the look and feel of the case when it's housing a system inside? Well, the plastic finish at the front proved divisive in the office, but the two RGB fans lurking behind the facade, along with one at the rear, are a nice touch for nu-school gaming aesthetes who like every component and peripheral in sight to be color-matched and synched. These can be hooked up to Asus, Gigabyte, and MSI RGB boards, and tweaked using the respective manufacturer's software suite to apply just the right (read: wrong) shade of wedding-disco lighting. In terms of finish quality, there are minimal rough or sharp edges inside the case upon which you could damage a fleshy finger or arm, and our only real complaint is that the tempered glass side panel doesn't sit quite flush with the case, but protrudes a few fractions of an inch further. In other words: No, the look and feel don't tarnish the bargainous nature of this package either.

So, we're altogether at a loss as to why someone wouldn't pick this for their budget build, or even a mid-range build with its priorities in place. After all, it always makes sense to spend more on the bits inside the case and go a tad frugal with the exterior—not that lit fans and glass panels are all that frugal.... Unless you really need more than three drives installed, this should be your first consideration for a sub-$100 case. –PHIL IWANIUK

VERDICT **9**

Cooler Master MasterBox MB500

COOLIO Amazing value; easy to build in; smart finish.

VANILLA ICE Limited drive capacity.

$70, www.coolermaster.com

SPECIFICATIONS

Form Factor	Mid-tower
Motherboard Support	ATX, microATX, Mini-ITX
3.5-inch Support	Up to 2
2.5-inch Support	Up to 4
Radiator Support	Up to 360mm (front), up to 120mm (rear)
Dimensions	19.4 x 8.3 x 18.7 inches
Graphics Card Clearance	15.7 inches
CPU Tower Clearance	6.3 inches
Weight	16.3lb

Boomer is a friendly hound who retrieves guns in battle.

The vast draw distance does justice to the Montana landscape.

A truck with machine guns mounted on the front isn't subtle, but it sure is fun.

It's simple to swap between guns and homeopathic stat-enhancers.

Far Cry 5

Bringing the good news to the people of Hope County

AN OPEN WORLD, an exotic location, and a madman. The ingredients of a *Far Cry* game have mixed well up till now, but the fifth mainline game drops the exotic location part, and ups the nut count to compensate.

Thrown into the age-old conflict between backwoods doomsday cult and law enforcement, your character is, of course, a rookie, sent in to arrest the top psychopath just before everything starts to explode. Upon escaping the cult's clutches, you vanish into the Montana wilderness to organize a resistance movement, liberate towns, and recruit AI companions to help with the fight. You can do it in co-op, too.

The Eden's Gate cult isn't like Heaven's Gate, despite a similar liking for assault rifles. For a start, there are thousands of them. Kidnapping and brainwashing with a drug called Bliss seems to be their MO, but other than that their beliefs are ill-defined.

Not that this matters, because they're just there to be shot at, no matter that they used to be Hope County's inhabitants. *Far Cry 5's* map is huge, and without the constant stream of hostages to rescue, treasure to discover, and men with flamethrowers to blow up, it could be accused of being bland. The magnificent trees and mountains of Big Sky Country are all present, but unlike *Far Cry 4's* tight map, which funneled you across its two regions, Montana consists of a lot of open space.

By dumping the series's often derided radio towers, fast travel locations, enemy outposts, and missions pop up as you explore. Best are the Prepper Stashes, which are not only fun but go a long way to filling your arsenal. Abandoned caches of weapons and money left by doomsday preppers, they're a self-contained puzzle with a juicy reward at the end.

Joseph Seed, a performance taken from a hitherto undiscovered Jared Leto audition tape, makes for a dangerous big boss, yet his followers are responsible for the game's great annoyance—using drugged bullets, they're able to capture you repeatedly, make you do something, then let you go. As a way of forcing "boss" encounters, it's effective, but deeply irritating all the same. Another bugbear comes in the form of "angels"—zombie-like drug addicts who rush you and soak up bullets.

Much better is Far Cry Arcade, the newest incarnation of the map editor. Custom maps can be played solo, in co-op, or deathmatch, and the simplicity of laying out the assets is unmatched.

Far Cry 5 is a strange beast. In some ways, the most refined version of Ubisoft's open-world chaos formula we've seen, yet unwilling to commit to the positions it sets up for itself. It wins hugely in terms of looks and sheer breadth of stuff to do, but loses out in the personality stakes. **–IAN EVENDEN**

VERDICT 8

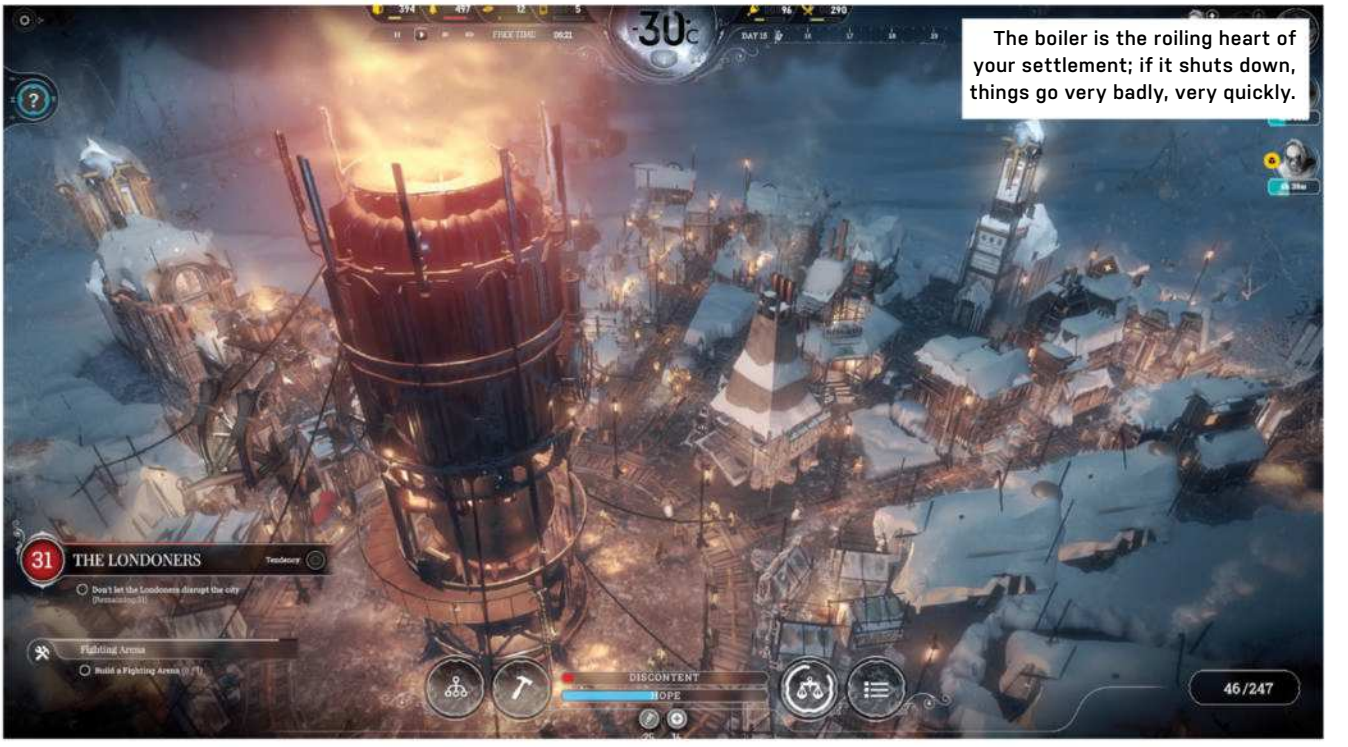
Far Cry 5

FAR Beautiful world; no shortage of things to blow up.

CRY We miss the tropics; bad guys fall flat; forced boss encounters annoy.

RECOMMENDED SPECS Core i7-4770, AMD Ryzen 5 1600, or equivalent; 8GB RAM; GeForce GTX 970 or AMD R9 290X.

$60, http://far-cry.ubisoft.com, ESRB: M



The boiler is the roiling heart of your settlement; if it shuts down, things go very badly, very quickly.

Frostpunk

All that glisters is very cold

ALT-HISTORY STEAMPUNK city building? We're there. Prospective metropolitan planners should beware, however, because *Frostpunk* isn't quite the chilly *Sim City* it might at first appear to be.

For a start, there's that name. It tells us nothing, apart from that things are frosty. The story goes that, in the 1800s, Earth froze over. One group of survivors set out from London, UK, and established a new city, huddled around a coal-fired heat generator, inside the sheltering walls of a crater. This didn't stop the temperature regularly falling to -40 C, nor constant snowfall building up on the roofs.

As the captain, or supreme dictator, of this new settlement, believed to be the last city on Earth, it's your job to keep everybody alive. You start out with 40 homeless citizens and a single steam boiler to keep them warm, but both these figures rise over the course of the game. You begin carrying out the usual city building and management tasks—constructing houses, gathering resources—when the game hits you with a question. Do you want to make children work?

Obviously, as a 21st century, relatively civilized person, the answer would be "no." But you're from Victorian London, a place where children regularly carried out chimney cleaning and industrial work, for which their small hands were perfect, even if it meant losing a finger or two. Of course you're going to put them to work. At least you're given the option of not sending them into the most dangerous jobs. This is the future of humanity you're safeguarding here, after all.

COLD COMFORT

Frostpunk requires, at times, for you to be as cold as the wind that blows more snow into your crater. It's a trait the game has inherited from its developers' previous work, *This War of Mine*, in which the ugly consequences of your actions were not shied away from. *Frostpunk* is the same. Make poor, or at least unpopular, decisions and you'll have a riot on your hands. Be seen as a benevolent ruler, and a group of disabled people and amputees will offer to work in your cookhouse if you fashion them basic prosthetics. The fact that you have to refuse through lack of research and resources is just too bad.

Teams of scouts, sent out into the wider wilderness to scavenge for supplies and look for more survivors, are your only contact with the outside world. Losing a team that's laden with booty before it can make its way back to your city is a punch in the gut. Setting your municipality on the road to fascism by enacting laws designed to promote public order and keep the red Discontent bar from filling is something you think about long after you've stopped playing. The gradual progress of the blue Hope bar, on the other hand, soothes your panic, and makes you feel that just maybe you're going to come out of this OK.

It's not a difficult game, as long as you stay on top of the need for constant resources, and it's beautiful to look at—the trudging of your citizens through chest-deep snow and the spindly legs of the *Dishonored*-like robots you construct to automate production contrast nicely with a game that's mostly shades of white, gray, and orange. And unlike many city management games, it has a defined ending, with no endless mode. What it is, however, is difficult to forget. –IAN EVENDEN

VERDICT 9

Frostpunk

CHILLY Moral decisions resonate; intricate graphical style; not very difficult to finish.

SILLY Road building is awkward; occasionally not clear how to achieve goals.

RECOMMENDED SPECS 3.2GHz quad-core CPU; 8GB RAM; GeForce 970, Radeon RX 580, or equivalent, with 4GB of VRAM.

$30, http://frostpunkgame.com, ESRB: M

LAB NOTES

ZAK STOREY, DEPUTY EDITOR

The Rise & Fall of Empires

The problem with social media in today's interconnected age

"IDEAS HAVE UNHINGED the gates of empires." Those seven little words are perhaps more astute today than they have ever been.

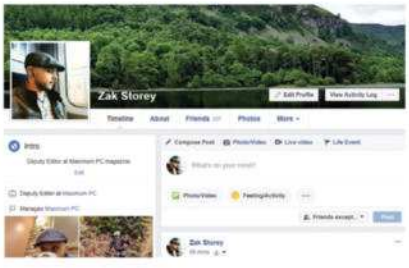
In a highly volatile world, the notion of collective knowledge bringing about upheaval is far more common than it once was. We've seen it happen around the world, time and time again. And to some degree, even here in the US, too, as the political landscape twists and turns into something new. For good or ill, the world is changing, and on a grand scale.

As long as the digital channels remain open, communication flows, and education continues, change is more likely to occur. This is called progress. At least, that's the theory. And although we have undeniably seen fantastic things happen since the birth of the Internet, I'm not so convinced that it's the force for good that we once perceived it to be.

In my eyes, the problem is down to humanity's desire to group together with like-minded people. Nowadays, social media more often acts as an echo chamber than a valuable means of discussion. And I confess to being a hypocrite, because I'm very much a contributor to that reality.

I've made hundreds of acquaintances over the years, who on the surface, at least, have been good folk. But like many others, I've removed, blocked, and hidden lots of them from my social channels. Not because I disliked them, but because I didn't agree with them. It was far easier for me to brush their opinions under the rug than witness them, or talk about the points being raised.

The reality is that I now sit in newsfeeds filled with people I agree with, talking



about things I already know. There's no meaningful discussion here, no education, no change—I learn nothing. Those gates that were once open, continually challenged, now lie locked, buried beneath a cesspool of stagnating thought. Change is happening, sure, but I fear it falls more on the side of regression, of isolation, and not on the side of progress.

JARRED WALTON

Senior Editor

I miss the days of massive CPU overclocks, relative to stock clocks. I started my own overclocking journey with Intel's original Pentium, when I took a 166MHz model and successfully managed to run it at 250MHz. My next major upgrade was a Celeron 300A, which had a stock clock of 300MHz, and I overclocked it to 450MHz. Those are both 50 percent overclocks, on air cooling.

Advances in CPU tech have increased clock speeds, but the opportunities for overclocking are far more limited, largely because we're running into frequency limitations more often now, and higher performance CPUs usually include more cores instead of higher clock speeds. Intel's Core i7-8700K has clocks of 4.3–4.7GHz, and all-core overclocks of 5.0GHz or less—a 15 percent increase at best. AMD's Ryzen 7 2700X runs at 3.8–4.3GHz, but all-core overclocks of only 4.2GHz are typical. Going to a Core i9 or Threadripper can more than double core counts, but platform and architectural trade-offs reduce per-core performance. For overclocking, your best bet is a Core i5-8600K or Ryzen 5 2600. You can get an all-core overclock that's 20–25 percent higher than stock on the i5-8600K, and 10–15 percent higher on the Ryzen 5 2600. Too bad there's no way to unlock additional cores, because the i7-8700K and Ryzen 7 2700X are still faster.

Editors' Picks:
Digital Discoveries

Alan Dexter, executive editor, and Bo Moore, technology editor, share their binary and audio finds

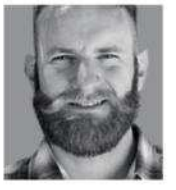
IPERF

How fast is your network? Not in theory, and not just the infrastructure, but how fast is it in real terms? It's a question I recently found myself investigating, and I happened upon a neat little tool called iPerf that answers just that by testing the TCP, UDP, and SCTP throughput of your network.

It's not only free, but there are plenty of pre-compiled versions for you to play with on a variety of platforms, too—from Windows to Android, with a swathe of Linux and macOS builds along the way. Basically, whatever machines you've got connected to your network, you should find a version of iPerf that works with it.

In order to use iPerf3, you need at least two machines: one acting as the server and the other as a client, although you can have several clients stressing your server if you wish. You also need the IP address of the server. Pop into a command prompt on the machine that will act as a server, and type "ipconfig"—you'll see the IP address next to "IPv4 Address." You need to download iPerf on to all the machines you want to test with. Once done, you can start one in server mode with the command "iperf3.exe -s" to set it up listening for the clients.

Download the same software on to another of your machines, and run it with the following command: "iperf3.exe -c {IP Address of server}"—replace the bit in curly brackets with the IP address from your server. Once done, you should find that you're looking at a readout of your network's throughput. There are plenty of options to play around with, although at its most basic, this should be enough to get you started.
$Free, www.iperf.fr



LOGITECH G560 LIGHTSYNC

I use a headset for most of my gaming, so when I upgraded to my current monitor, I didn't mind that it didn't have built-in speakers. I didn't have much need for playing game music out loud, but I will admit it was annoying not being able to play a song or video for my roommate.

This month, I finally found a set of speakers worth adding to my desktop setup. Logitech's G560 Lightsync has solid sound, with built-in DTS:X virtual surround, and a powerful subwoofer, but what really sets it apart is the integrated RGB lighting.

I'm not normally one for extravagant RGB setups, but the Lightsync software does more than just cycle a rainbow of colors ad nauseam. I set mine up to extend colors from the edges of my screen using rear-facing LEDs, to create an immersive lighting experience. The result is subtle mood lighting behind my rig, without being annoying. Even better, it syncs up with my games to flash certain colors when I get hit or need to reload, or when someone pings me in Discord.
$200, www.logitechg.com

GEEK TESTED & APPROVED

Gloomhaven

THERE ARE BOARD GAMES. There are great board games. And then there's Gloomhaven. Rated as the top game on BoardGameGeek in 2017, Gloomhaven is that rarest of things—legendary in its own lifetime. The Kickstarter campaign saw nearly $4 million pledged, smashing through the $100K goal. The initial printing was in such great demand that prices skyrocketed, and even now you can expect to pay $200 to get your hands on a copy. *(And not a cryptocurrency in sight—Ed).*

That's a lot of money for a tabletop game, but amazingly, it's worth it. There is so much to this co-operative dungeon crawler that the box alone weighs over 20 pounds, with character miniatures, player sheets, combat cards, monster cards, equipment, counters, and more. There's an inherent excitement that comes with simply setting all these parts up for a scenario, but the core mechanics of the game are what really make it such a great experience.

The real genius of the game is the way the combat works—there are no dice rolls here; instead, each player has a limited number of combat cards to fight the various monsters you encounter. Over the course of a dungeon, you use up these cards, then have to rest to get them back (losing a card in the process). The scenario balance is brilliant, too, so that you often either succeed or fail just as you're down to your last cards. Gloomhaven has an incredible reputation, but somehow it manages to live up to the hype. **–AD**
$140, www.cephalofair.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Password Preference
> Gaming on Linux
> Which Wireless Gear?

Password Picks

I found your article on passwords and password managers interesting, but I wonder if you have been paying attention, because you failed to mention one of the earliest and feature-filled password managers: RoboForm. I haven't done an exhaustive comparison between RoboForm and LastPass, but I think they offer pretty much the same capabilities. **–Ben Maltz**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: There are lots of password managers out there, and most of them are capable enough, so when it comes to a recommendation, we tend to go with the ones we've had most experience with. LastPass has always served us well, which is why we tend to talk about it, but if you've used RoboForm and you're happy with its service, by all means keep using it. Likewise, if you use Dashlane, KeePass, Sticky Password, or anything else, there isn't necessarily a reason to switch.

Linux Gaming

Your article on Linux gaming was very informative, but apparently things have only gotten a little simpler. OK, a graphic wrapper for Wine is a decent start, and Steam for Linux helps. But I want to know what happened to the software engineers who got this right. It wasn't recent (2002), but *Neverwinter Nights* got it right. The install was simple (OK, you needed a Windows box to get the files from the CD to your HDD, but who doesn't have that?), and the game ran flawlessly. Like most everything else, it even ran better on Linux with inferior hardware. (My friend's rig was better, but my game ran smoother, and I hosted all the online games.) The game was fully functional, with all community functions, online multiplayer, editors, custom maps, and so on working.

I really thought this was going to get the ball rolling for real gaming on Linux. Where did these geniuses go? Why has nobody else tried this approach? Did Bill Gates and/or Gabe Newell send the Clinton hit squad to wipe these people out? I know that *NWN* was a top-notch game that served its wares up to the nerdiest of nerds, but other genres have people just as passionate, so I don't get why more developers/publishers didn't go about doing this. **–Paul**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We're with you on this Paul, and assumed that the industry would have shifted to a platform-agnostic model far more than it has. While the SteamOS concept didn't really take off—we'd have been surprised if it did—we still expected something more constructive to come out of it. And to be fair to the industry, we have seen more and more games making their way to Linux, but it isn't the groundswell we (and many others) would have predicted.

Part of the problem is development time, which when combined with the size of markets (Windows still accounts for 96 percent of the market on the latest Steam survey), means many big games don't get the love they deserve. At least there are lots of tools now, which should make it easier for games to run on different PC platforms (such as Vulkan).

Wireless Dongles

Would you ever consider doing a feature on wireless USB adapters? There are so many of them that it makes me wonder: Are they all technically about the same, because they all use the same technology, or do their drivers make them different? I rely on Amazon product reviews to get an idea of whether one is better than another. Also, will it be time soon for a review of wireless routers?

–Ron Dewar

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: There is a range of chipsets used by Wi-Fi dongles, but for most normal use, they're much of a muchness—just make sure they work under Windows 10, and you should be good to go. If you have a specific task in mind (running on a Raspberry Pi, say, or doing some packet sniffing), you'll have to dig into the details a little first, but there are plenty of compatibility lists for such situations.

We haven't used a dongle in a while, but suspected that these tiny adapters would be very cheap, and a quick look on Amazon confirmed this, with plenty of dongles available for around $10 or less. To this end, it's worth checking

↘ submit your questions to: comments@maximumpc.com

out the most popular ones, and seeing what users think of them. As far as our recommendations go, we tend to side with well-known names (Netgear, TP-Link, and so on), but this isn't a hard rule, especially not at this end of the market.

As for the wireless router roundup, it's still on our list of forthcoming features, but we're waiting for a shift in the market before we pull the trigger, because it seems to have stagnated a little lately. Maybe the popularity of mesh routers means that we should be looking at those more than just stand-alone routers.... Let us know your thoughts.

Wrong Path

I just want to let you know that there is a "typo" in the setup instructions for the "Build a Raspberry Pi Wireless Access Point" article on pages 54–57 in the May 2018 issue of *Maximum PC*. On page 55, the path to hostapd.conf is set to be /etc/hostapd/hostapd.conf, but on page 56 the path is set to /etc/hostapd.conf (in the part where DAEMON_CONF is configured in the file /etc/default/hostapd). It is also set to /etc/hostapd.conf under section 7 in the article, on page 56.

This might lead to problems for readers trying to set the AP up and get it working. Other than that, the article works flawlessly!

–Jonas

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We admit that this maybe isn't quite as clear as it could be, but at the same time, it also may not be as straightforward as you think, because there are actually two instances of the file in question. There's the original one that you leave untouched in /etc/hostapd/, then there's the one that is used by the project, which can be found in /etc/default/, and that's the one we point to at the end of step 5 and in step 7. As long as you've got it working, though, that's all that matters.

[NOW ONLINE]

INTEL REFLECTS ON MOORE'S LAW AS 50-YEAR ANNIVERSARY LOOMS

Over the years, Intel has insisted that Moore's Law is alive and well, even when others have declared it dead. Now, as the company approaches its 50th anniversary, Intel is taking a moment to reflect on five decades of processor design, and how the prediction of one of its co-founders would serve as its guiding principle even to this day.

It all started with a paper published on April 19, 1965, entitled "Cramming More Components onto Integrated Circuits." In that paper, Moore had predicted that the number of components that could fit into a state-of-the-art microchip would double around every year for the next decade. He was essentially talking about transistors, which he said would lead to more powerful chips that would ultimately power home PCs and "automatic controls for automobiles."
Read the full article at: https://bit.ly/2L17EXu

Open Coverage

Thanks for the ongoing Linux coverage. The Wine ("Play Windows Games in Linux") article in your May 2018 issue was great. **–Richard**

Better Comparison

Going back to the $300 build of March 2017, which has now become $500, in a letter published in March 2018, I commented on your July 2017 "Build It Special," and in your response you said you would be doing a one-on-one comparison at a later date. I'm glad you put together such a computing scenario—a decent price/performance ratio for a budget build that can do decent graphics processing, given today's insane memory and graphics card prices. AMD and Intel PCs that for all intents and purposes are one and the same. Since I'm in Canada, the cost here is $610, not including tax.

As you say, Zak, the true value of a PC is in the low to medium price range, where 80 percent of us operate, not in the $2,500-$4,700 range of July 2017's stratospheric prices! One thing your article didn't mention was what role Vega processors play in machine learning, augmented reality, and so on, rather than just gaming. Nonetheless, we're getting "Maximum" value from a PC, regardless of the name, with "Minimum BS."

–Murray McCullough

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Glad you enjoyed the article. We have a few more of these direct comparisons planned, at a range of prices, so hopefully we can keep you interested.

Better than Mac

Is the Apple Mac better at video editing than a PC? I've always been told it's true in terms of ease of use, video format, codec compatibility, video editing stability, universally accepted DVD/Bluray compatibility, wide range of camcorder import compatibility, speed of rendering, and quality of edited output.

If this is not true, what three PC builds can you publish in your next magazine (low, moderate, and high cost) that would crush all of the Apple Mac's superior video editing features? Please include software recommendations that will take advantage of hardware features, as well as be compatible and stable with the hardware selected.

–Mark Belgen (frustrated videographer and PC user)

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: There's no reason from a hardware perspective why this should be the case, because as I'm sure you know, a modern Apple Mac is simply a PC anyway. Which means that the only difference between a machine running OSX and your average Windows machine is the software. And, actually, there isn't much difference on the software front either—the likes of Avid Media Composer, Lightworks, and Premiere Pro are all available on both platforms. There is one tool that Apple does lay claim to, though, and that's Final Cut Pro, which has been used on plenty of big films, and it does benefit from running on a closed platform. Even so, one piece of software isn't enough to warrant the idea that Macs are better than PCs for video editing. When it comes to building machines that would be good at video editing, then consider us intrigued. It's not quite the remit of the builds at the back of the magazine, but it's definitely something that we could look into in a feature. Watch this space.

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THE BUILDS

BUDGET

INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$47
PSU	450W Corsair CX450	$40
Mobo	ASRock AB350M-HDV	$65
CPU	AMD Ryzen 5 2400G	$163
GPU	N/A	$0
RAM	8GB (2x 4GB) G.Skill RipJaws 4 DDR4-3200	$104
SSD	120GB Adata Ultimate SU650 2.5-inch SSD NEW	$34
HDD	Hitachi Deskstar E7K1000 1TB 7,200rpm	$38
OS	Ubuntu Desktop Linux 18.04 LTS 64-bit NEW	$16

Approximate Price: $507

THERE AREN'T MANY CHANGES for the budget build this month, which is fine, because we're happy with the makeup. We did see a drop on the pricing of the case, down to $47 from $59, which was welcome, because it's great value even at full price. The memory sticks went up a whole buck, but there wasn't anything better to choose from, so we sucked that up. The only real change was on the storage front, as our budget SSD of choice, the 120GB Kingston A400, saw a $5 increase. Not the end of the world, but when you're trying to save money, this isn't the kind of shift we like to see. Thankfully, there was a sale on Adata's SU650, which saw its normal pricing of $50 slashed by $16, so we grabbed that instead. Performance is slightly better than the Kingston, too, so we see this as a win all around. You'll also spot that we've shifted over to the Long Term Support build of Ubuntu 18.04, because that offers better support for AMD Raven Ridge.

MID-RANGE

INGREDIENTS

PART		PRICE
Case	Fractal Design Meshify C	$75
PSU	550W Corsair RM550X	$100
Mobo	MSI Z370 Tomahawk	$130
CPU	Intel Core i5-8400	$180
Cooler	Be Quiet! Dark Rock 3	$75
GPU	EVGA GeForce GTX 1060 Gaming ACX 2.0 3GB NEW	$250
RAM	16GB (2x 8GB) Patriot Viper Elite DDR4-2400	$160
SSD	250GB Samsung 970 Evo M.2 PCIe SSD NEW	$110
HDD	Hitachi Deskstar E7K1000 1TB 7,200rpm	$38
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $1,218

IT HAS FINALLY HAPPENED: Graphics card pricing has returned to reasonable levels! We managed to save $20 on the graphics card in this machine compared to last month, for the same performance. We were tempted to go for the 6GB version instead, but wanted to keep the price low, though we wouldn't scold you if you decided to spend more. We also snapped up a $20 saving on the MSI mobo. It's worth noting that these savings can throw things a little when it comes to bundles. For instance, the combo of this motherboard and the Core i5-8400 usually makes for a serious saving, but as the board is on sale, it only equates to a $5 saving when bundled. It's worth checking the pricing on bundles before you pull the trigger. We saw a $5 increase on the memory front, but given the saving elsewhere, decided it wasn't worth changing things. We did replace the Samsung 960 Evo with the 970 Evo, though, as it's not only faster, but it's $10 cheaper as well.

UPGRADE OF THE MONTH

NVIDIA GEFORCE GTX 1060 6GB

We usually highlight one of the components from one of our builds here, but this month we're not; we're recommending a graphics card that many have been putting off until prices and stock levels returned to normal. The 6GB spin of the GeForce GTX 1060 is an incredibly capable mid-range card that can handle everything 1080p gaming can throw at it. Unfortunately, it hit ridiculous pricing levels recently, so didn't quite add up as the perfectly priced pixel-pusher that it was originally released as. With the pricing back to normal levels, it can wear the value crown once again, and the likes of the tiny MSI card pictured will fit in an impressive array of small builds as well. If money is a bit tight, the 3GB spin offers great value, too, which is why we've used that in our mid-range build. It feels like it's a good time for PC gaming again, now these cards are more affordable.

$300, www.nvidia.com

THERE AREN'T A LOT OF CHANGES with our high-end "Turbo" build this month, bar two exceptions. We still saw plenty of movement on the pricing of some components, though. The case went up $8, while the motherboard was $10 cheaper. We also saw a return to the lower pricing of the Threadripper chip, back down to the $700 that we were accustomed to. This is partially in anticipation of the next-gen Threadripper chips that are due out before the year ends, but don't let that put you off buying one of these amazing chips right now.

Graphics card pricing at the high end continues to be volatile, and over the course of a weekend we saw the cost of the 1080 Ti swing by as much as $100. Cards could be had for as low as $750 for a while, only to bounce back to $850 once demand heated up. Even at this price, it's a $100 saving over last month. It's worth keeping an eye on the official Nvidia store, as you could grab a Founders Edition at the RRP of $700 (there have been a few cards in stock, but they sell out very quickly).

The other big change with our Turbo build this month is the move to the Samsung 970 Pro. We've been running the 960 Pro for a while, and have been really happy with the performance on offer, so the switch to the newer drive really shouldn't come as a surprise, even if it does carry a $45 premium over what is now the last-gen drive. That extra cash does net you the fastest consumer drive around right now, which is reason enough for us to recommend it, even at this price.

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART		PRICE
Case	NZXT H700i	$184
PSU	Corsair RM750X Modular Gold	$110
Mobo	ASRock X399 Taichi	$339
CPU	AMD Ryzen Threadripper 1920X	$700
Cooler	NZXT Kraken X62	$160
GPU	Gigabyte GeForce GTX 1080 Ti 11GB NEW	$850
RAM	32GB (4x 8GB) G.Skill Ripjaws V Series DDR4-3200	$369
SSD	512GB Samsung 970 Pro M.2 NVMe NEW	$370
HDD	2x 2TB Seagate BarraCuda ST2000DM006	$120
OS	Windows 10 Home 64-bit OEM	$100
Approximate Price:		**$3,302**

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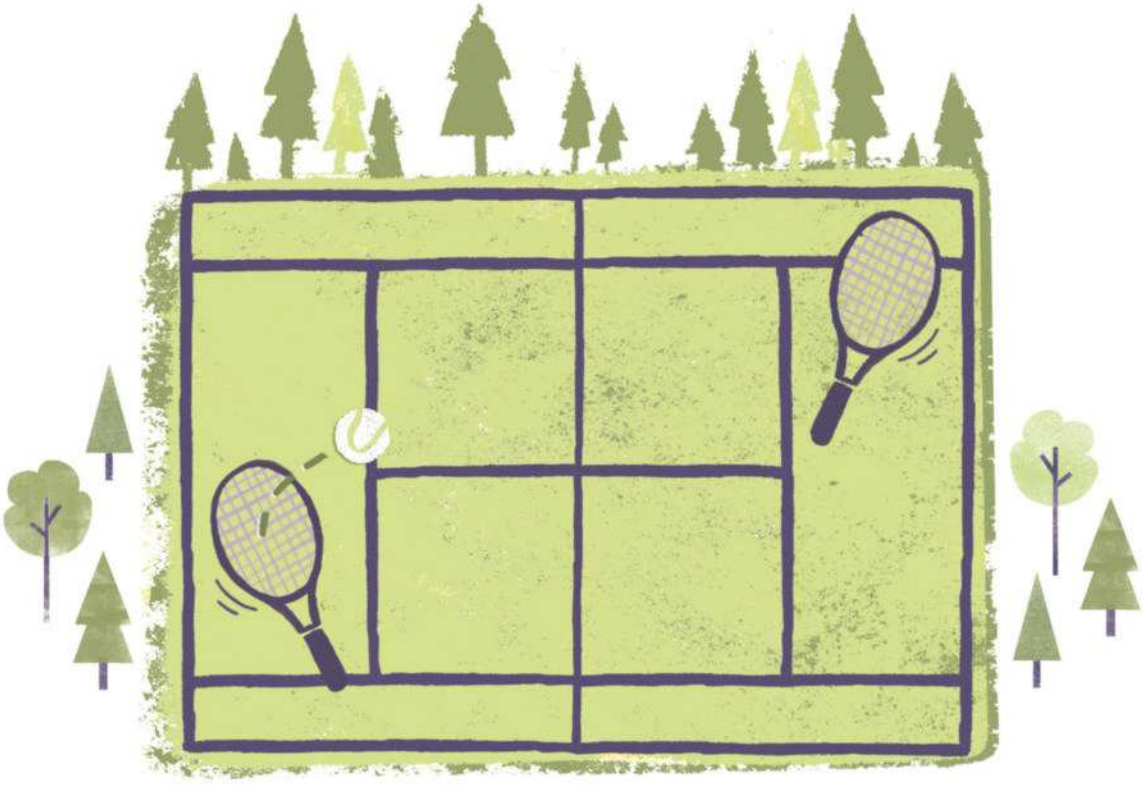

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UNFAO, Global Forest Resources Assessment 2005-2015

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